

## RECYCLING MATERIALS IN CONSTRUCTION

Cristina Alexandra MINCA<sup>1</sup>, Rodica Mariana ION<sup>1,2,3\*</sup>

<sup>1</sup> Valahia University of Targoviste, Doctoral School of Materials Engineering, 13 Aleea Sinaia, 130004, Targoviste, Romania

<sup>2</sup> ICECHIM, 202 Splaiul Independentei, 060021, Bucharest, Romania.

<sup>3</sup> Academy of Romanian Scientists, 3 Ilfov Street, 050044 Bucharest, Romania.

E-mail: rodica\_ion2000@yahoo.co.uk

**Abstract:** This paper presents a detailed and critical review of recycled materials used in the construction industry, with emphasis on sustainability, efficient use of resources, and reduction of environmental impact. The analysis is based on recent studies focused on construction and demolition waste (CDW), including materials such as recycled concrete aggregates (RCA), plastics, metals, glass, and industrial by-products like fly ash and slag. The comparison of multiple research works shows that recycling processes, material composition, and treatment techniques play an important role in determining the mechanical properties, durability, and environmental behavior of recycled construction materials. The results indicate that using recycled materials can lead to lower greenhouse gas emissions, reduced energy consumption, and decreased landfill disposal, while still ensuring acceptable performance in many structural applications. At the same time, several limitations must be considered. These include variations in material properties, higher water absorption in recycled aggregates, and the absence of clear standards for large-scale use. In addition, the study highlights the importance of modern recycling technologies, life cycle assessment (LCA) methods, and circular economy principles in improving the overall efficiency and reliability of these materials. Future research should focus on improving processing techniques, increasing durability, and developing advanced materials such as hybrid and smart systems. Overall, the use of recycled materials in construction can be considered an important step toward a more sustainable and low-carbon built environment.

**Keywords:** recycling, construction materials, sustainability, circular economy

### 1. INTRODUCTION

The construction sector is widely recognized as one of the major consumers of natural resources and a significant source of global waste, especially through construction and demolition waste (CDW) [1,2]. Recent research shows that CDW represents a considerable share of the total solid waste generated worldwide, leading to serious environmental and economic concerns [2,3]. At the same time, the growing demand for raw materials such as aggregates, cement, and metals has contributed to the depletion of natural resources and to increased greenhouse gas emissions [1,4].

Under these conditions, recycling materials in construction has become an important approach for supporting sustainable development and limiting environmental impact. As noted by Wu et al. [3], the reuse and recycling of construction materials can reduce landfill volumes and carbon emissions, while also improving the efficiency of resource use. In a similar way, Ma et al. [4] indicate that the use of recycled materials, especially recycled concrete aggregates (RCA), can lower the

consumption of natural aggregates without significantly affecting mechanical performance. Even so, the use of recycled materials is not without challenges. Several studies highlight certain limitations that must be considered. For example, Janani et al. [5] point out that variations in material properties and potential durability issues can influence performance in specific applications. At the same time, Sumikura et al. [6] emphasize the absence of consistent regulations and the lack of uniform recycling practices across different regions. Experimental studies conducted by Contreras et al. [8] also show that although recycled materials can achieve acceptable strength, their behavior depends strongly on processing techniques and material composition. In addition, the success of recycling in construction is closely linked to the technologies used during material processing. Bampanis et al. [7] demonstrate that improved recycling methods, including better sorting and treatment processes, can increase the quality and performance of recycled materials, making them more suitable for structural use. Furthermore, life cycle assessment (LCA) methods have been widely applied to evaluate their environmental

benefits, confirming their ability to reduce both energy consumption and environmental impact [3,7]. For these reasons, the purpose of this paper is to present a comprehensive and comparative review of recycled materials used in construction. The study examines their types, processing methods, mechanical and environmental performance, as well as their practical applications. By bringing together results from different studies, the paper aims to provide a balanced perspective on both the advantages and the limitations of recycled materials, while also outlining important directions for future research in sustainable construction.

## 2. CONSTRUCTION MATERIALS AND SUSTAINABILITY

The construction industry depends to a large extent on traditional materials such as concrete, steel, and asphalt, which are known for their significant environmental impact due to energy-intensive production processes and high levels of carbon emissions [1,4]. Among these, cement production plays a major role, being responsible for a substantial proportion of global CO<sub>2</sub> emissions. As a result, concrete is often considered one of the most environmentally impactful construction materials [1]. In recent years, this has increased the interest in identifying more sustainable alternatives. Recycled materials have been extensively studied as a practical solution for reducing the environmental footprint of construction activities. According to Wu et al. [3], replacing natural aggregates with recycled concrete aggregates (RCA) can considerably reduce the need for raw material extraction as well as overall energy consumption. In a similar context, Ma et al. [4] show that using recycled components as partial substitutes for virgin materials can lead to noticeable reductions in greenhouse gas emissions, especially when transportation distances and processing requirements are kept low.

Besides aggregates, industrial by-products such as fly ash and blast furnace slag are widely used as supplementary cementitious materials. These materials can improve mechanical performance and durability while also decreasing the amount of cement required [1,5]. Janani et al. [5] point out that their use not only contributes to sustainability but can also enhance long-term performance, particularly in terms of resistance to chemical attack and thermal stability. However, their effectiveness is influenced by factors such as composition, treatment processes, and compatibility with the cement matrix. The environmental advantages of recycled construction materials are often assessed using life cycle assessment (LCA) methods. Research by Bampanis et al. [7] and Wu et al. [3] indicates that recycled materials can significantly reduce both embodied energy and overall environmental impact throughout the life cycle of a structure. These results underline the importance of considering the entire life cycle, including production, transport, processing, and disposal stages.

Even though the benefits are clear, the widespread use of recycled materials still faces several challenges. Sumikura

et al. [6] highlight issues such as inconsistent material quality, lack of standardized regulations, and various institutional barriers that limit large-scale adoption. In addition, recycled aggregates typically present higher porosity and increased water absorption compared to natural aggregates, which can negatively influence durability and mechanical performance [4,8]. Experimental findings by Contreras et al. [8] confirm that, although acceptable strength levels can be achieved, the final performance is strongly dependent on processing techniques and mix design. Recycled materials offer a promising solution for more sustainable construction practices. However, their successful application requires better quality control, clearer regulations, and optimized processing methods. The use of advanced recycling technologies together with improved material design strategies is essential to maximize their potential while ensuring adequate structural performance.

## 3. TYPES OF RECYCLED MATERIALS IN CONSTRUCTION

Recycled materials used in the construction sector are mainly derived from construction and demolition waste (CDW), industrial by-products, and various post-consumer waste streams. In recent years, these materials have been increasingly adopted as more sustainable alternatives to traditional construction resources, mainly due to their ability to reduce environmental impact and preserve natural raw materials [1,3]. Their performance in practical applications is influenced by several factors, including their origin, the processing techniques applied, and their compatibility with existing construction materials and systems [4,5].

### 3.1. Recycled Concrete Aggregates (RCA)

Recycled concrete aggregates (RCA) represent one of the most commonly used recycled materials in the construction industry. They are produced through the crushing and processing of demolished concrete elements and can be utilized as partial or even complete substitutes for natural aggregates in concrete production and road infrastructure applications [2,4].

As reported by Ma et al. [4], RCA can provide mechanical properties similar to those of natural aggregates when used at moderate replacement levels, typically between 30% and 50%. However, increasing the replacement ratio may result in a decrease in compressive strength, mainly due to the presence of residual mortar and the higher porosity of the material. In the same context, Contreras et al. [8] show that RCA generally exhibits greater water absorption and lower density, factors that can negatively influence durability if appropriate treatment methods are not applied. At the same time, the environmental advantages of RCA should not be overlooked. Wu et al. [3] underline that the use of recycled aggregates reduces the need for natural resource extraction and contributes to lowering carbon emissions. Moreover, recent studies indicate that advanced treatment techniques, such as

carbonation or surface modification, can significantly improve the physical and mechanical properties of RCA, making it more suitable for structural applications [7].

### 3.2. Recycled Metals

Recycled metals, especially steel and aluminum, play an important role in sustainable construction due to their high recyclability and their ability to maintain mechanical properties even after multiple recycling cycles [6]. Among these, steel is particularly valuable, as it can be reused repeatedly without significant loss of strength, which makes it one of the most sustainable materials used in construction.

According to Sumikura et al. [6], recycling metals leads to a substantial reduction in energy consumption compared to primary production processes, with energy savings that can reach between 60% and 90%, depending on the type of material. In addition, the use of recycled steel contributes to lowering greenhouse gas emissions and supports the principles of a circular economy. Despite these advantages, the recycling of metals requires efficient sorting and proper treatment in order to ensure consistent quality and performance. The presence of contaminants and variations in recycled metal streams can affect material properties and may limit their use in applications that require high performance [5].

### 3.3. Recycled Plastics

Plastic waste has become an increasingly attractive alternative material in the construction field, especially in applications such as asphalt mixtures, bricks, insulation panels, and composite products [5]. The use of recycled plastics can enhance certain properties, including flexibility, resistance to moisture, and overall durability in specific applications. Janani et al. [5] indicate that asphalt modified with plastic shows improved resistance to deformation and cracking, which makes it suitable for use in road construction. In addition, incorporating recycled plastics can reduce the overall weight of construction elements and improve their thermal insulation performance. However, compared to conventional construction materials, plastics generally have lower stiffness and mechanical strength, which limits their use in structural applications. Furthermore, Wu et al. [3] highlight that potential long-term environmental effects, such as the release of microplastics, should be carefully evaluated when considering the use of plastic-based materials in construction.

### 3.4. Recycled Glass

Recycled glass is frequently used in construction as a replacement for fine aggregates in concrete, as well as in decorative architectural applications [2]. When properly processed, crushed glass particles can enhance certain properties of the material, including durability and resistance to chemical attack. One of the main challenges associated with the use of recycled glass is the risk of

alkali-silica reaction (ASR), which may cause expansion and cracking in concrete structures [4]. To reduce this risk, it is necessary to apply appropriate measures such as fine grinding of the glass and careful optimization of the mix design. Even with these limitations, recycled glass plays an important role in reducing landfill waste and supports the development of more sustainable material cycles, especially in urban areas where glass waste is widely available [3].

### 3.5. Industrial By-products (Fly Ash, Slag, etc.)

Industrial by-products such as fly ash, blast furnace slag, and silica fume are commonly used as supplementary cementitious materials in concrete production [1,5]. Their incorporation can improve mechanical properties, increase durability, and enhance resistance to chemical attack, while also reducing the overall demand for cement. Alsheyab et al. [1] report that the use of fly ash and slag can significantly improve long-term strength and decrease permeability, resulting in concrete with better resistance to environmental degradation. In a similar way, Janani et al. [5] highlight that these materials contribute to lowering CO<sub>2</sub> emissions associated with cement production, supporting more sustainable construction practices. However, the effectiveness of industrial by-products is influenced by their availability and quality, which depend on the specific industrial processes from which they are obtained. Variations in composition can affect their performance, making proper material characterization and strict quality control essential for their successful use in construction applications [4].

## 4. RECYCLING PROCESSES IN CONSTRUCTION

The recycling of construction materials consists of several interconnected processes designed to recover valuable components from construction and demolition waste (CDW) and reintroduce them into the production cycle. The quality and efficiency of the resulting recycled materials are strongly influenced by the processing techniques applied, as these directly affect their mechanical properties, durability, and overall performance [2,4].

### 4.1. Collection and Sorting

The initial stage of the recycling process involves the collection and separation of construction waste materials. Proper sorting plays a key role in maintaining the quality and purity of recycled materials, especially in applications where high performance is required [2]. As highlighted by Bolden et al. [2], inadequate sorting can result in contamination, which negatively affects mechanical properties and reduces the usability of recycled materials. To address this issue, advanced sorting methods have been developed, including automated systems and sensor-based technologies, which improve material separation and minimize contamination levels [7].

In addition, Wu et al. [3] point out that selective demolition practices, where materials are separated directly at the source, can significantly increase recycling efficiency and lower processing costs. This method also enables better recovery of high-quality materials such as concrete, metals, and glass.

#### 4.2. Crushing and Processing

Following the sorting stage, materials such as concrete and masonry are subjected to crushing and mechanical processing in order to obtain recycled aggregates. The crushing process is particularly important, as it directly influences the particle size distribution, shape, and surface characteristics of the resulting materials [4]. Ma et al. [4] emphasize that the quality of recycled concrete aggregates (RCA) depends greatly on the crushing method used, with multi-stage crushing techniques producing more uniform and higher-quality materials. However, the presence of adhered mortar increases both porosity and water absorption, which can negatively affect the overall performance of the aggregates. To overcome these limitations, several advanced processing methods have been developed, including mechanical grinding, thermal treatment, and carbonation. According to Bampanis et al. [7], carbonation treatment can enhance both the density and strength of RCA, while also contributing to a reduction in CO<sub>2</sub> emissions.

#### 4.3. Treatment and Quality Improvement

In order to improve the performance of recycled materials, different treatment techniques are applied to enhance their physical and chemical characteristics. These methods include surface treatments, washing processes, chemical stabilization, and coating technologies [5,7]. Janani et al. [5] show that treating the surface of recycled aggregates can significantly decrease water absorption and improve the bond between the aggregates and the cement matrix. In a similar way, chemical treatments and the use of specific additives can increase durability and provide better resistance to environmental conditions.

For recycled plastics and metals, processing methods such as melting, extrusion, and refining are commonly used to restore material properties and ensure uniformity [6]. However, these techniques must be carefully controlled, as improper processing can lead to material degradation or contamination.

#### 4.4. Reuse and Integration into New Materials

The final stage of the recycling process consists of incorporating the processed materials into new construction products. Recycled materials can be applied in a wide range of uses, including concrete production, road works, and prefabricated elements [3,4]. Wu et al. [3] point out that the performance of recycled materials in construction is influenced not only by their intrinsic properties, but also by factors such as mix design and

specific application conditions. For instance, the partial replacement of natural aggregates with recycled concrete aggregates (RCA) can preserve structural performance while contributing to improved sustainability.

In addition, Contreras et al. [8] show that, when appropriate processing techniques and optimized mix designs are used, recycled materials can achieve mechanical properties similar to those of conventional materials. On the other hand, improper integration may negatively affect durability and overall structural behavior.

#### 4.5. Emerging Recycling Technologies

Recent developments in recycling technologies have considerably improved both the efficiency and sustainability of material recovery processes. These advancements include automated sorting systems, artificial intelligence-based identification methods, and advanced treatment techniques such as carbonation and thermal processing [7].

Bampanis et al. [7] highlight that these technologies contribute to improving the quality of recycled materials while also reducing energy consumption, which makes recycling more economically feasible. Furthermore, the use of digital tools allows for better monitoring and optimization of recycling operations.

However, despite these technological improvements, several challenges still limit their widespread application. Issues related to scalability, high costs, and practical implementation remain significant concerns. Sumikura et al. [6] note that the adoption of advanced recycling technologies is often constrained by economic factors and regulatory limitations, especially in developing regions.

### 5. MECHANICAL AND ENVIRONMENTAL PERFORMANCE

The performance of recycled materials in construction is generally assessed based on their mechanical properties, durability, and environmental impact. These aspects are influenced by several factors, including the type of material, the processing methods applied, and the proportion of replacement, which makes comparative evaluation essential for determining their suitability in engineering applications [3,4].

#### 5.1. Mechanical Performance

The mechanical performance of recycled materials, especially recycled concrete aggregates (RCA), has been widely investigated in recent years. As reported by Ma et al. [4], RCA can reach compressive strength values similar to those of natural aggregates when used at moderate replacement levels, typically up to 30–50%. However, higher replacement ratios tend to reduce strength, mainly due to increased porosity and the presence of adhered mortar. In the same context, experimental studies by Contreras et al. [8] show that recycled materials can achieve acceptable mechanical

properties, although their performance is strongly influenced by processing quality and mix design. Their findings indicate that proper treatment and grading of recycled aggregates can significantly enhance compressive strength and improve structural reliability. On the other hand, Janani et al. [5] point out that recycled materials may present lower tensile strength and reduced stiffness compared to conventional materials, particularly when they are used without adequate treatment. This limitation becomes critical in structural applications where high mechanical performance is required.

At the same time, Wu et al. [3] suggest that hybrid solutions, such as combining recycled aggregates with supplementary cementitious materials like fly ash or slag, can compensate for the reduction in strength and improve overall performance. This observation is supported by Alsheyab et al. [1], who show that the use of industrial by-products enhances bonding characteristics and reduces microstructural imperfections.

Overall, recycled materials can provide satisfactory mechanical performance, but their effectiveness largely depends on appropriate processing methods, careful material selection, and well-controlled replacement ratios.

## 5.2. Durability and Long-Term Behavior

Durability represents a key aspect in assessing recycled construction materials, as it directly influences their long-term behavior under various environmental conditions. In general, recycled aggregates tend to show higher water absorption and permeability due to their increased porosity, which can have a negative impact on durability [4,8].

Ma et al. [4] indicate that the higher porosity of recycled concrete aggregates (RCA) makes them more vulnerable to freeze-thaw cycles and chemical attack. In a similar way, Janani et al. [5] point out that untreated recycled materials may degrade more rapidly than natural materials, especially when exposed to aggressive environments.

Despite these limitations, durability can be improved through appropriate treatment methods and material optimization. Bampanis et al. [7] demonstrate that advanced processing techniques, such as carbonation and surface treatments, can significantly enhance durability by reducing porosity and improving the microstructure of the material. Moreover, the incorporation of supplementary cementitious materials, including fly ash and slag, has been shown to increase resistance to chemical attack and decrease permeability [1,5]. These materials contribute to the development of denser and more stable microstructures, which improves long-term performance.

## 5.3. Environmental Performance

One of the most important advantages of using recycled materials in construction is their positive impact on the environment. A large number of studies show that recycling construction waste can significantly reduce

greenhouse gas emissions, lower energy consumption, and decrease the demand for natural resources [3,7]. Wu et al. [3] demonstrate that the use of recycled aggregates helps reduce carbon emissions by limiting the need for extraction and transportation of virgin materials. In a similar manner, Bampanis et al. [7] report that advanced recycling processes can reduce the overall environmental footprint of construction materials by improving efficiency and minimizing energy use. Furthermore, incorporating industrial by-products such as fly ash and slag reduces the need for cement, which is one of the most carbon-intensive materials used in construction [1]. This leads to a considerable decrease in CO<sub>2</sub> emissions and supports more sustainable construction practices.

However, as highlighted by Sumikura et al. [6], the environmental benefits of recycling are influenced by several factors, including transportation distances, processing energy requirements, and the availability of local infrastructure. In certain situations, inefficient recycling systems may limit or even reduce the expected sustainability advantages.

## 5.4. Comparative Analysis of Performance

A comparison of the analyzed studies shows that the performance of recycled materials is not uniform, but varies depending on the type of material and the processing techniques applied. Wu et al. [3] mainly focus on environmental aspects, emphasizing the role of recycling in reducing carbon emissions. In contrast, Ma et al. [4] concentrate on mechanical behavior, highlighting both the potential and the limitations related to strength and durability. Janani et al. [5] discuss the variability of recycled materials and the practical challenges associated with their use in real construction conditions. At the same time, Contreras et al. [8] provide experimental evidence regarding the performance of recycled materials under controlled conditions, while Bampanis et al. [7] underline the importance of advanced technologies in improving material quality and performance.

Overall, these studies suggest that there is no single optimal solution applicable in all cases. The effective use of recycled materials requires a balanced approach that takes into account mechanical performance, durability, and environmental impact.

## 6. APPLICATIONS AND FUTURE TRENDS

In recent years, recycled materials have attracted growing interest due to their potential to be used in a wide variety of construction applications. Their implementation not only supports environmental sustainability but also improves economic efficiency by lowering material costs and reducing waste disposal needs [3,7].

### 6.1. Applications in Construction

Recycled materials are currently applied in a wide range of construction uses, including both structural and non-structural applications. One of the most common areas of

use is road construction, where recycled concrete aggregates (RCA) and recycled asphalt are frequently utilized as base and sub-base layers [2,4].

Bolden et al. [2] indicate that recycled aggregates can provide sufficient compaction and load-bearing capacity, making them suitable for pavement systems. In a similar way, Ma et al. [4] show that RCA can be incorporated into concrete for non-structural purposes and, in certain cases, for structural applications, provided that proper mix design and quality control measures are applied. Recycled materials are also increasingly used in building components such as blocks, bricks, panels, and insulation systems. According to Janani et al. [5], the use of recycled plastics and industrial by-products can improve thermal insulation and reduce the overall weight of construction elements, contributing to better energy efficiency in buildings.

In addition, recycled metals, especially steel, are widely used in structural applications due to their high strength and excellent recyclability [6]. Sumikura et al. [6] emphasize that using recycled steel significantly lowers energy consumption and carbon emissions compared to primary production, making it an essential material for sustainable construction.

Moreover, Contreras et al. [8] demonstrate that recycled materials can be successfully integrated into innovative construction solutions, such as environmentally friendly bricks and composite materials, when appropriate processing techniques and material optimization are applied.

### **6.2. Integration in Sustainable and Circular Construction**

The use of recycled materials is strongly connected to the principles of the circular economy, which focus on reducing waste and improving resource efficiency. Wu et al. [3] emphasize that the reuse and recycling of construction materials play an essential role in closing material loops and minimizing environmental impact.

Bampanis et al. [7] further explain that circular construction systems depend on efficient recycling processes, proper material tracking, and optimized design approaches. This also involves designing buildings in such a way that they can be easily disassembled, allowing materials to be recovered and reused at the end of their service life.

Within this framework, life cycle assessment (LCA) methods are widely used to evaluate the sustainability of recycled materials and to support decision-making in construction projects [3,7]. These methods help identify the most efficient material solutions and improve environmental performance throughout the entire life cycle of a structure.

### **6.3. Future Trends and Research Directions**

Future developments in the field of recycled materials for construction are expected to focus on advanced technologies, improved material performance, and greater

sustainability. One of the main directions is the development of smart and hybrid materials that combine recycled components with modern additives in order to enhance mechanical properties and durability [1,5].

At the same time, emerging technologies such as artificial intelligence (AI) and automated sorting systems are likely to improve the efficiency and accuracy of recycling processes [7]. These innovations allow better identification, separation, and quality control of materials, helping to reduce variability and improve overall performance.

Another important trend is the transition toward fully circular construction systems, where materials are continuously reused and recycled, minimizing waste generation. Wu et al. [3] underline that achieving this goal requires close collaboration between industry, policymakers, and researchers in order to establish clear regulations and promote sustainable practices.

Despite these promising developments, several challenges still need to be addressed. Economic limitations, insufficient infrastructure, and regulatory barriers continue to restrict the large-scale implementation of recycled materials [6]. As noted by Sumikura et al. [6], the successful adoption of these materials depends on the development of well-defined standards, appropriate incentives, and supportive policies that encourage sustainable construction.

## **7. CONCLUSIONS**

This paper has provided a comprehensive and comparative analysis of recycled materials used in the construction industry, emphasizing their potential to contribute to sustainable development and to reduce environmental impact. The reviewed studies confirm that construction and demolition waste (CDW) can be efficiently converted into valuable resources, helping to decrease landfill disposal and preserve natural materials. The findings indicate that recycled materials, particularly recycled concrete aggregates (RCA), industrial by-products, and recycled metals, are capable of achieving acceptable mechanical performance. At the same time, their performance is influenced by factors such as material composition, porosity, and treatment techniques, which can lead to variations in strength and durability. From an environmental perspective, the use of recycled materials offers clear advantages, including reduced greenhouse gas emissions, lower energy consumption, and more efficient use of natural resources. In addition, the -intensive materials in construction.

In conclusion, recycling materials in construction represents an essential step toward achieving a circular and low-carbon built environment. Through the combined use of technological innovation, optimized material design, and supportive policies, recycled materials can play a key role in the transition toward more sustainable construction practice. acceptable mechanical performance when suitable processing methods and optimized mix designs are applied.

Future research should concentrate on improving processing techniques, enhancing durability through advanced treatments, and developing clear standards for the use of recycled materials. At the same time, the integration of emerging technologies, including artificial intelligence and advanced sorting systems, has the

potential to further improve the efficiency and quality of recycling processes  
incorporation of supplementary cementitious materials such as fly ash and slag contributes to improved sustainability by decreasing the dependence on cement, one of the most carbon.

#### REFERENCES

- [1] Alsheyab, M. A., et al., *Recycling of Construction and Demolition Waste: A Review*, Journal of Environmental Management, 2021.
- [2] Bolden, J., Abu-Lebdeh, T., Fini, E., *Utilization of Recycled and Waste Materials in Various Construction Applications*, American Journal of Environmental Science, 2013, 9(1), 14–24.
- [3] Wu, J., et al., *Recent Advances in Recycling Construction Materials and Circular Economy Approaches*, Journal of Cleaner Production, 2025.
- [4] Ma, Y., et al., *Mechanical and Environmental Performance of Recycled Concrete Aggregates: A Review*, Construction and Building Materials, 2024.
- [5] Janani, R., et al., *Reuse and Recycling of Materials in Construction: A Comprehensive Review*, Materials Today: Proceedings, 2022.
- [6] Sumikura, T., et al., *Policies and Practices for Sustainable Construction and Recycling Materials*, Sustainability, 2021.
- [7] Bampanis, I., et al., *Advanced Recycling Technologies for Construction Materials*, Resources, Conservation and Recycling, 2023.
- [8] Contreras, M., et al., *Experimental Study on Recycled Materials in Construction Applications*, Construction and Building Materials, 2021.
- [9] Poon, C.S., Kou, S.C., Lam, L., Use of recycled aggregates in molded concrete bricks and blocks, *Construction and Building Materials*, 2002, 16(5), 281–289.
- [10] Tam, V.W.Y., Gao, X.F., Tam, C.M., Microstructural analysis of recycled aggregate concrete produced from two-stage mixing approach, *Cement and Concrete Research*, 2005, 35(6), 1195–1203.
- [11] Thomas, C., Setién, J., Polanco, J.A., Alaejos, P., Sánchez de Juan, M., Durability of recycled aggregate concrete, *Construction and Building Materials*, 2013, 40, 1054–1065.
- [12] Siddique, R., Utilization of industrial by-products in concrete, *Resources, Conservation and Recycling*, 2008, 52(2), 252–260.
- [13] Ghisellini, P., Cialani, C., Ulgiati, S., A review on circular economy: The expected transition to a balanced interaction of environmental and economic systems, *Journal of Cleaner Production*, 2016, 114, 11–32.
- [14] Akhtar, A., Sarmah, A.K., Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective, *Journal of Cleaner Production*, 2018, 186, 262–281.
- [15] Kou, S.C., Poon, C.S., Properties of self-compacting concrete prepared with recycled glass aggregate, *Cement and Concrete Composites*, 2009, 31(2), 107–113.
- [16] Evangelista, L., de Brito, J., Mechanical behaviour of concrete made with fine recycled concrete aggregates, *Cement and Concrete Composites*, 2007, 29(5), 397–401.