

Sustainable Construction Practices: A Review on Utilization of Construction and Demolition Waste in Concrete

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Abstract:

The rapid urbanization and infrastructure growth worldwide have intensified the generation of construction and demolition (C&D) wastes, contributing significantly to environmental degradation and natural resource depletion. Conventional concrete production relies heavily on river sand, gravel, and cement, all of which have adverse ecological impacts due to unsustainable extraction. This study explores the potential of using C&D waste materials specifically sawdust and waste glass as partial replacements for fine aggregates in concrete. The mechanical and physical properties of concrete composites incorporating these alternative materials were evaluated, with emphasis on compressive strength, water absorption, machinability, and durability. The review of existing literature further highlights the effectiveness of supplementary cementitious materials (SCMs) such as silica fume, metakaolin, and ground granulated blast-furnace slag (GGBS), along with other industrial by-products like steel-scale waste, waste foundry sand, and recycled aggregates. Findings demonstrate that optimized incorporation of sawdust, glass waste, and SCMs can produce sustainable concrete with acceptable structural performance while reducing environmental burdens. This study underscores the viability of recycling C&D waste into concrete composites as a sustainable pathway toward greener construction practices.

Keywords: Cement, Sand, Waste Material, Aggregate, Concrete, Silica, Dust, Broken Glass.

1. Introduction

The management of solid waste has emerged as one of the most pressing environmental and social challenges worldwide. In many cities, construction and demolition (C&D) wastes, including cementitious debris, sawdust, and other building materials, are often disposed of in landfills without adequate recycling or reuse. This not only contributes to environmental degradation but also accelerates the depletion of natural resources, particularly when riverbed and beach sand are excessively exploited for use as fine aggregates in concrete. To address this challenge, the utilization of C&D waste materials as partial replacements for conventional raw materials in

concrete offers a sustainable and eco-friendly solution.

In this study, sawdust derived from construction activities was investigated as a partial substitute for fine aggregates in concrete composites. The feasibility of incorporating demolition waste and construction by-products into concrete mixtures was explored with a focus on their mechanical and physical performance. Demolition waste, generated from the dismantling of deteriorated or cracked buildings, constitutes a significant portion of annual solid waste—approximately 25% originating from existing structures and nearly 75% from new construction projects. The fine particles obtained from crushing and

processing of such waste materials can be repurposed in flooring systems, lightweight components, packaging, and other construction applications.

Sawdust, when used as a replacement material, exhibits a higher water absorption capacity compared to natural fine aggregates. This influences the workability, strength development, and durability of the resulting concrete. The study evaluates key parameters such as compressive strength, water absorption, machinability, and other physical properties of concrete composites incorporating varying proportions of sawdust. The findings demonstrate that partial replacement with sawdust and demolition waste not only reduces environmental impact but also offers a promising pathway toward sustainable construction practices.

2. Coarse Glass Pieces

One of the major challenges associated with glass is its disposal. Glass is widely used in applications such as juice and beverage bottles, making it one of the most common packaging materials. In 2016, glass was estimated to account for nearly 5% of global municipal solid waste, with recycling rates varying significantly across regions. For instance, in 2017, the average glass recycling rate in Europe was 71.48%, with Slovenia and Belgium achieving rates as high as 98%, while Turkey recorded only 9%. In contrast, the United States reported a recycling rate of 26.63% in 2017, with approximately 52.9% of large glass bottles ending up in landfills.

Glass waste poses a critical environmental challenge, as it is non-biodegradable and remains indefinitely in landfills. Inefficient recycling and disposal practices increase reliance on natural resources, particularly sand, which is required to manufacture new glass products. This dependency not only contributes to environmental degradation but also escalates the demand for landfill space. Consequently, several regions have introduced landfill taxes to promote higher recycling rates.

Glass, produced primarily from natural materials such as sand, is a durable and

valuable resource. While a large portion of waste glass is recycled into new glass products, a significant amount still finds its way into landfills, occupying considerable space. To mitigate this issue, alternative recycling pathways must be explored. One promising avenue is the construction sector, which is responsible for nearly 8% of global carbon emissions. Given the heavy reliance of this sector on sand and cement, the incorporation of waste glass into concrete composites represents a sustainable approach to reducing environmental impacts while conserving natural resources.

3. Sawdust

This In the construction and building sector, sawdust is not conventionally employed as a raw material, primarily due to the widespread availability of sand and gravel or due to reservations regarding its performance in structural applications [5]. However, in many developing countries, the need for affordable construction materials has encouraged the use of indigenous and alternative resources to reduce costs.

Sawdust, a by-product of wood processing, consists of fine wood particles produced during sawing and cutting operations. When clean and free from impurities, sawdust has shown potential as a supplementary construction material. Studies have demonstrated that partial replacement of sand with sawdust commonly around 10% can yield concrete with acceptable compressive strength. Moreover, environmental assessments confirm that sawdust is free from harmful toxins, making it safe for construction purposes. Although sawdust exhibits higher water absorption compared to natural aggregates, proper mix design can mitigate this drawback. Thus, sawdust offers a sustainable alternative for partial replacement in concrete production.

4. Advantages of Using Construction and Demolition (C&D) Waste in Concrete

- C&D waste is generated during the construction, renovation, repair, and demolition of buildings, bridges, roads, ports, dams, and other infrastructure.

- Typical debris includes wood, steel, concrete, plaster, masonry, stucco, metal, and asphalt.
- Recycling C&D waste reduces the demand for new raw materials, thereby conserving natural resources and mitigating landfill overcrowding.
- Several studies highlight that the incorporation of C&D waste significantly reduces construction costs.
- Recycling saves expenses related to landfill management, reduces packaging needs, and creates employment opportunities in recycling industries.

5. Literature Review

Several studies have explored the use of recycled aggregates (RA) and industrial by-products in sustainable concrete production. Haider et al. (2025) investigated recycled aggregate concrete (RAC) with metakaolin (MK) and silica fume (SF), reporting that an optimum mix of 50% RA, 10% MK, and 5% SF improved strength, durability, and thermal stability due to pozzolanic activity. Similarly, Basnett et al. (2025) demonstrated that surface-treated recycled aggregates combined with olivine sand enhanced mechanical strength (45.43 MPa at 28 days), bond strength, and microstructural density, highlighting TMRAOS as a cost-effective and eco-friendly alternative.

Kumar et al. (2024) emphasized the role of supplementary cementitious materials (SCMs) such as SF, GGBS, and mechanically produced fines in improving RCA quality and ITZ bonding, thereby achieving performance comparable to natural aggregate concrete. Nawaz et al. (2024) showed that steel-scale waste (SSW) could replace natural sand in high-performance concrete, achieving compressive strengths up to 140 MPa, with durability benefits particularly at 50% replacement.

Other studies have assessed combined materials and fibers. Jamil et al. (2023) found that incorporating jute fibers at low dosages (0.15%) improved mechanical properties of RCA concrete, though higher dosages reduced

durability. Ubachukwu et al. (2022) showed that optimizing the water–cement ratio (0.40–0.50) improved the compressive strength of sawdust-based concrete. Ahmad et al. (2022) advocated the use of waste foundry sand (WFS) as an eco-friendly alternative to river sand.

Several industrial by-products have also been proposed as cement replacements. Adamu et al. (2021) demonstrated that calcium carbide residue (CCR) blended with nano silica improved strength and reduced cement usage. Chouhan et al. (2021) reported Kota stone slurry could replace cement up to 10% without significant strength loss, while Raid Hussain (2021) confirmed that silica fume and CKD lowered emissions and maintained adequate concrete properties. Jangid et al. (2021) and Ibrahim (2021) further highlighted the potential of sawdust, glass powder, and other wastes as partial replacements for cement and aggregates, with optimal substitution levels required to balance sustainability and performance.

Overall, the literature demonstrates that incorporating recycled aggregates and industrial by-products enhances the sustainability of concrete production while maintaining or even improving mechanical and durability performance when optimized properly.

6. Conclusion

This study emphasizes the potential of incorporating sawdust and glass waste as partial replacements for fine aggregates in concrete, contributing to sustainable construction while addressing the disposal challenges of C&D waste. Sawdust enhances cost-effectiveness and promotes the reuse of by-products, though its higher water absorption requires careful mix design to maintain workability and strength. Waste glass, on the other hand, provides a durable and resource-efficient substitute for natural sand, reducing landfill accumulation and conserving raw materials. The review of past studies confirms that recycled aggregates, SCMs, and industrial by-products can significantly improve the mechanical and durability

properties of recycled aggregate concrete when used in optimized proportions. Overall, the integration of C&D waste into concrete not only reduces reliance on natural resources but also lowers environmental impacts, supporting circular economy principles in the construction sector. Future research should focus on long-term durability, microstructural characterization, and life-cycle assessments to validate the large-scale adoption of these sustainable practices.

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