RESEARCH ARTICLE OPEN ACCESS

Sustainable Utilization of Construction and Demolition Waste: Partial Replacement of Cement, Sand, and Aggregate in Concrete

Md. Shah Faisal*, Vikas Kumar**

*M.Tech Student, Department of Civil Engineering, Arya Institute of Engineering and Technology, Jaipur, Rajasthan, India

** Assistant Professor, Department of Civil Engineering, Arya College of Engineering, Jaipur, Rajasthan, India

Abstract:

This study explores the feasibility of utilizing construction and demolition (C&D) waste as a substitute material in concrete composites. A large portion of this waste originates from the demolition of historic buildings carried out to address structural damage and cracks, while new construction activities also generate significant quantities of waste. Overall, it is estimated that approximately 25% of solid waste is produced annually by existing buildings, and nearly 75% arises from new construction projects. In this research, glass waste obtained from construction and demolition activities was used due to its pozzolanic properties, which are comparable to cement, making it a suitable partial replacement in concrete. The waste glass, primarily collected from discarded containers, was crushed and ground into a fine powder resembling cement particles. Other industrial by-products such as silica dust, industrial sand, recycled debris, broken glass, and sawdust commonly available in urban areas were also considered, although their recycling and reuse remain minimal. Strict environmental regulations combined with limited landfill capacity have made industrial waste disposal a pressing challenge. In this context, reusing these materials in concrete composites presents a sustainable solution. This paper specifically evaluates the effectiveness of sawdust as a partial replacement in concrete and investigates the role of fine and dense aggregates in formwork design. Experimental trials were conducted in which conventional concrete components were gradually replaced with crushed waste materials. The performance of the modified concrete was assessed through compressive strength tests at curing ages of 7 and 28 days.

Keywords: Cement, Waste Material, Sand, Concrete, Compressive Strength, Silica, Dust, Broken Glass, Constructional.

1. Introduction

The problem of solid waste management is one of the most pressing environmental and social challenges faced by countries worldwide. In many urban areas, construction-related waste such as cement residues, aggregates, and other building materials is neither properly recycled nor effectively managed, often ending up in landfills. At the same time, the rapid pace of urbanization and infrastructure development places immense pressure on natural resources, particularly river and beach sand, which are extensively used as fine aggregates in concrete [1]. Overexploitation of these resources has led to environmental degradation, making it necessary to identify sustainable alternatives.

One viable solution is the reuse of construction and demolition (C&D) waste as a recycling material in concrete production [6]. Such an approach not only reduces the environmental burden of waste disposal but also contributes to the conservation of natural resources. In this study, sawdust derived from construction activities is considered as a partial replacement for fine aggregates in concrete. Sawdust, being lightweight and widely available, offers potential benefits; however, its high water absorption compared to natural sand can influence the properties of concrete, requiring careful investigation.

C&D waste is generated from both the demolition of old structures and the construction of new ones. It is estimated that approximately 25% of solid waste is generated annually from existing buildings undergoing repairs or demolition, while nearly 75% originates from new construction projects. The debris from these processes—commonly referred to as demolition waste—includes materials such as crushed concrete, wood, glass, and metals. Small crushed particles, typically used in flooring systems, packaging, lightweight construction components, and furniture, can be further processed into fine powders suitable for replacing conventional aggregates in concrete mixes.

This study investigates the feasibility of employing sawdust and other C&D waste materials as partial substitutes for conventional raw materials in concrete composites. The focus is on evaluating the mechanical properties, particularly compressive strength, along with other relevant characteristics such as durability, workability, and water absorption. Through this approach, the research aims to assess the potential of recycled waste materials to reduce reliance on natural aggregates while contributing to sustainable construction practices.

2. Mix Design of Prepared For Analysis

An M-25 grade compactor is used for this job. Replace the cement with 0%, 4%, 8% and 16% cement powder. The totals were replaced by 0%, 4%, 8% and 16% glasses. FA is replaced with 0%, 4%, 8% and 16% sawdust. There are two types of tests: working time and treatment time.

Here, CCP=Crushed Concrete Powder, CGP=Coarse Glass Pieces

Table 1: Mix samples for Testing Cement with CCP

No. of Mix	CCP	Cement
Mix-4	0%	100%
Mix-B	4%	96%
Mix-C	8%	92%
Mix-D	16%	84%

Table 2: Mix samples for Testing Coarse Aggregate with CGP

No. of Mix	CGP	Aggregate
Mix-I	0%	100%
Mix-II	4%	96%
Mix-III	8%	92%
Mix-IV	16%	84%

Table 3: Mix of M30 Concrete 0% substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

No. of Mix	CCP	CGP	Saw Dust
Standard	0%	0%	0%
Mix-1	0%	4%	4%
Mix-2	0%	8%	8%
Mix-3	0%	16%	16%

Table 4: Mix of M30 Concrete 4% substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

No. of Mix	CCP	CGP	Saw Dust
Mix-1	4%	0%	0%
Mix-2	4%	4%	4%
Mix-3	4%	8%	8%
Mix-4	4%	16%	16%

Table 5: Mix of M30 Concrete 8% substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

No. of Mix	CCP	CGP	Saw Dust
Mix-1	8%	0%	0%
Mix-2	8%	4%	4%
Mix-3	8%	8%	8%
Mix-4	8%	16%	16%

Table 6: Mix of M30 Concrete 16% substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

No. of Mix	CCP	CGP	Saw Dust
Mix-1	16%	0%	0%
Mix-2	16%	4%	4%
Mix-3	16%	8%	8%
Mix-4	16%	16%	16%

3. Result & Discussion

A. Results of Cement Test

Table 7: Consistency Test Due to Varying % of Cement Replaced with Crushed Concrete Power

No. of Mix	CCP	Cement	Consistency %
Mix-A	0%	100%	30.51
Mix-B	4%	96%	32.64
Mix-C	8%	92%	34.02
Mix-D	16%	84%	35.36

Table 8: Initial and Final Setting Time of Cement due to Varying % of Cement Replaced with Crushed Concrete Power (CCP)

No. of Mix	CCP	Cement	IST (min.)	FST (min.)
Mix-4	0%	100%	32	603
Mix-B	4%	96%	31	608
Mix-C	8%	92%	33	612
Mix-D	16%	84%	34	616

B. Results of Concrete Test

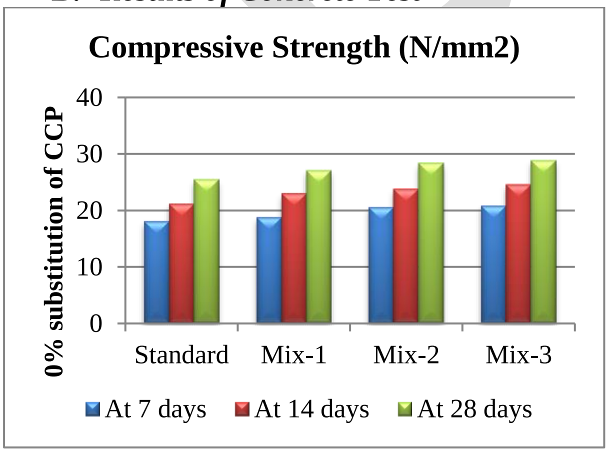

Figure 1: Concrete Compressive Strength Test at 7, 14 & 28 days Due to 0% Substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

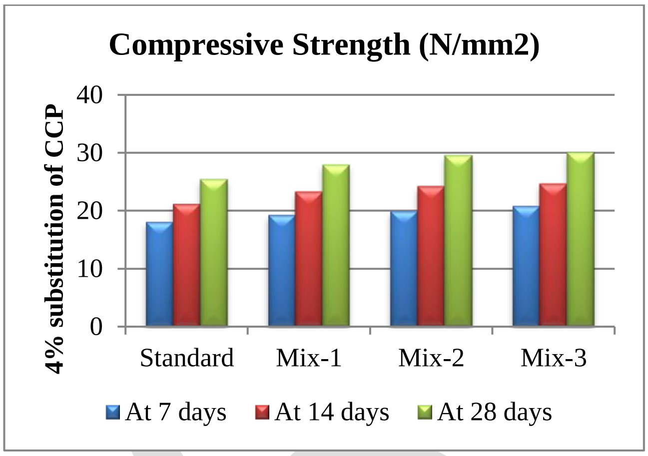

Figure 2: Concrete Compressive Strength Test at 7, 14 & 28 days Due to 4% Substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

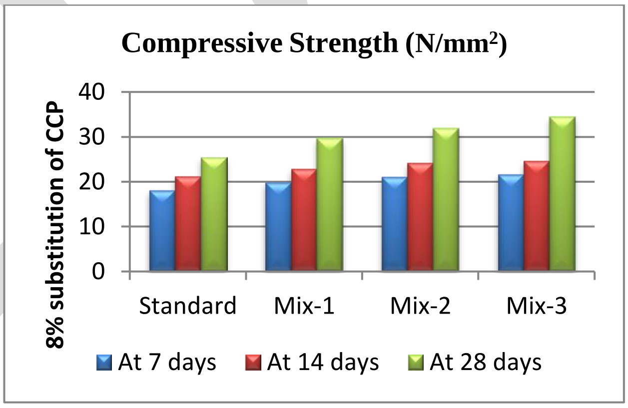

Figure 3: Concrete Compressive Strength Test at 7, 14 &28 days Due to 8% Substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

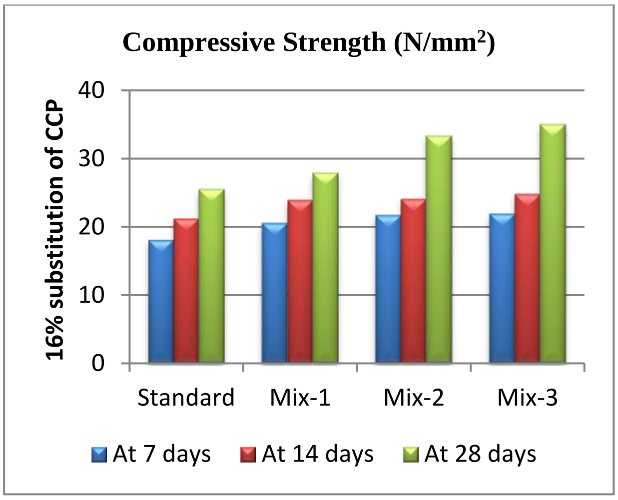

Figure 4: Concrete Compressive Strength Test at 7, 14 & 28 days Due to 0% Substitution of Cement with CCP and Varying % of Aggregate Replacement with Used CGP and Saw Dust

4. Conclusion

The experimental study shows that replacing cement with Crushed Concrete Powder (CCP) and aggregates with Crushed Glass Powder (CGP) and sawdust influences both fresh and hardened properties of concrete. Consistency, initial setting time, and final setting time of cement first decrease at certain replacement levels and then increase with higher CCP content. For aggregates, the impact and abrasion values increase with CGP, while crushing value decreases after an optimum level. Workability (slump) decreases with the addition of CGP and sawdust.

In terms of strength, compressive strength improved with CCP substitution up to 16%, showing maximum values in mix-3 across curing ages (7, 14, and 28 days). The highest 28-day compressive strength of 34.97 N/mm² was achieved at 16% CCP replacement with CGP and sawdust, indicating that partial substitution enhances mechanical performance while also promoting sustainable use of waste materials.

References

[1]. Hemant Kumar Sain, Anjali Verma, "An Overview and Use of Kota Stone Powder Slurry to Improve Engineering Properties of Soil Stabilization", International Journal of Engineering Trends and Applications (IJETA), Volume 12 Issue 4, Jul-Aug 2025.

[2]. Sain, H. K., Sharma, V., & Nisar, B. (2023). Effect of rock cracks on RC structures. AIP Conference Proceedings, 2901(1), 050005.

[3]. Soni, G. S., & Sharma, I. C. (2025). Sustainable concrete: Utilization of glass and sawdust waste in composite materials. International Journal of Engineering Trends and Applications (IJETA), 12(4).

[4]. Sharma, I. C., & Jonwal, A. K. (2014). Strength and durability properties of concrete using recycled concrete aggregate. International Journal (IJLCIET), 3(7).

[5]. Ganguly, G., & Sharma, I. C. (2017). Sustainable solid waste management, smart cities and Swachh Bharat initiative. Institute of Technology & Engineering, Jaipur.

[6]. Meena, D., Agwan, M. K., & Sain, H. K. (2023). An experimental study on the behaviour of concrete by partial replacement for rice husk ash, silica fume & iron slag with cement. International Journal of Engineering Trends and Applications (IJETA), 10.

[7]. Sharma, I. C., & Soni, G. S. (2024). Assessment of limestone dust and chips as eco-friendly alternatives in concrete production. International Journal of Engineering Trends and Applications (IJETA), 11(3).

[8]. Sharma, I. C., & Soni, G. S. (2024). Investigating progressive collapse in multi-story structures: Seismic load effects and belt wall remediation. International Journal of Engineering Trends and Applications (IJETA), 11(3), 51–58.

[9]. Goyal, N., Sain, H. K., & Agwan, M. K. (2022). A study on fiber reinforced concrete using different types of geo-polymer fiber in preparation of concrete sample. Journal of Emerging Technologies and Innovative Research (JETIR), 9(9), 750–753.

[10]. Choudhary, K., & Sain, H. K. (2021). Seismic behavioural analysis of one bay structure with composite beam and RCC columns. International Journal of Engineering Research and Generic Science (IJERGS), 7(6), 27–36.

[11]. Hemant Kumar Sain Gurmeet Singh, "Utilization of Sisal Fiber and Eggshell Waste as Sustainable Additives in Self-Compacting Concrete", International Journal of Engineering Trends and Applications (IJETA), Volume 12 Issue 4, Jul-Aug 2025.