

Comparative Study of Sand-Cement Blocks and Crushed Concrete Debris Blocks: A Case Study of Kigali City- Rwanda

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Abstract

This study investigates the potential use of crushed concrete debris as a sustainable alternative to sand-cement blocks in construction. The research evaluates the compressive strength, water absorption, and density of blocks made from recycled concrete debris and compares them with conventional sand-cement blocks. Results indicate that recycled concrete debris blocks exhibit higher compressive strength, comparable water absorption rates, and lower densities. These findings suggest that recycling concrete debris presents a viable solution for eco-friendly construction materials.

Keywords: Recycled concrete, sand-cement block, compressive strength, water absorption, density, sustainable construction

1. Introduction

The construction industry is continuously exploring sustainable alternatives to traditional materials to address the challenges of resource depletion and environmental degradation. Construction and demolition (C&D) waste, especially concrete debris, presents an opportunity to produce environmentally friendly building materials. Rwanda, like many developing nations, faces both high construction material costs and significant C&D waste. This study evaluates the feasibility of using crushed concrete debris in block production as an alternative to sand-cement blocks.

1.1 Problem Statement

Sand-cement blocks are widely used in Rwanda but are costly due to raw material availability and production processes. At the same time, the country faces issues with the disposal of concrete debris from demolished structures. This research explores whether crushed concrete debris can be repurposed into construction blocks, potentially reducing material costs and environmental impact.

1.2 Objectives

1.2.1 Main Objective

To compare the compressive strength, water absorption, and density of sand-cement blocks with those made from crushed concrete debris.

1.2.2 Specific Objectives

Evaluate the compressive strength, water absorption, and density of both block types.
Promote the use of recycled construction debris to minimize environmental impacts.

1.3 Significance of the Study

This study offers a pathway to reduce both construction costs and environmental harm by reusing concrete debris. The findings could lead to the development of cheaper building materials with performance characteristics comparable to or better than traditional sand-cement blocks.

2. Literature Review

Concrete is the world's most commonly used construction material, and sand-cement blocks are popular due to their strength and availability. However, researchers are increasingly exploring recycled materials, such as crushed concrete debris, as aggregates in new block production. Studies indicate that recycled aggregates can effectively replace traditional ones, reducing environmental impacts and material costs. Despite promising results, further research is needed to validate the long-term performance of recycled concrete blocks in real-world applications.

3. Methodology

This study adopts an “**Experimental comparative approach**” to compare the physical and mechanical properties of sand-cement blocks and blocks made from crushed concrete debris. The experimental approach involves conducting standardized tests to evaluate and analyze parameters such as compressive strength, density, and water absorption. By using this comparative methodology, the study can draw quantitative distinctions between the two types of blocks, allowing for a detailed understanding of their performance characteristics under similar conditions.

3.1 Materials

Raw materials, including fine sand, cement, and crushed concrete debris, are carefully sourced to meet quality standards. The sand and cement used for sand-cement blocks are compared with crushed concrete debris to determine the appropriate mix proportions.

3.2 Block fabrication

Each type of block is produced using standardized procedures to ensure consistency. Sand-cement blocks are made using a sand-to-cement ratio of 1:3, while blocks made from crushed concrete debris follow a ratio of debris-to-cement ratio of 1:2.

3.3 Testing Procedures

Physical Properties Testing: Each block type is evaluated for dimensions, weight, water absorption, and density following the BS standards

Mechanical Properties Testing: Compressive strength tests are conducted on both block types using a hydraulic press in accordance with BS EN 772-1.

4. Results presentation and Discussion

4.1. Results presentation

Test results are statistically analyzed to identify significant differences between the two block types. A comparative analysis is performed to highlight variations in physical and mechanical properties.

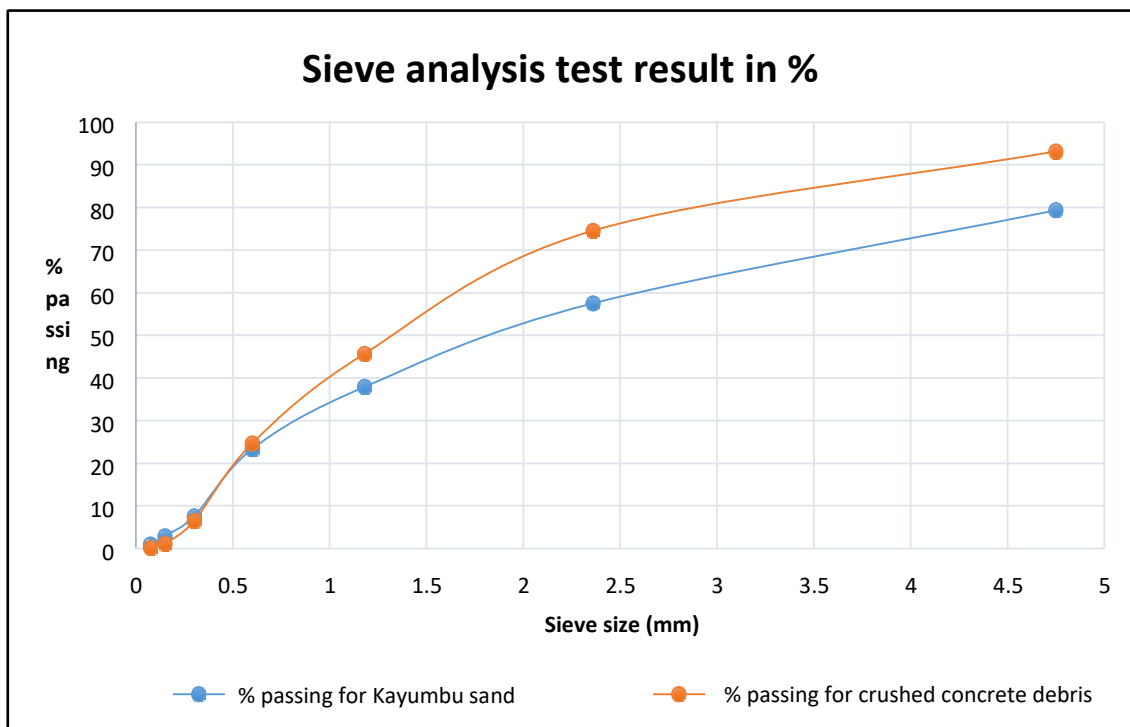
Sieve Analysis Test results –Kayumbu sand

Sieve Size (mm)	Weight Retained (g)	Cumulative Weight Retained (%)	Passing (%)
4.75	136	6.84	93.16

Sieve Size (mm)	Weight Retained (g)	Cumulative Weight Retained (%)	Passing (%)
2.36	373	25.45	74.55
1.18	570.5	54.3	45.7
0.600	418	75.33	24.67
0.300	360	93.53	6.47
0.150	108	98.86	1.14
0.075	20	99.82	0.18
Pan	3.5	100	0

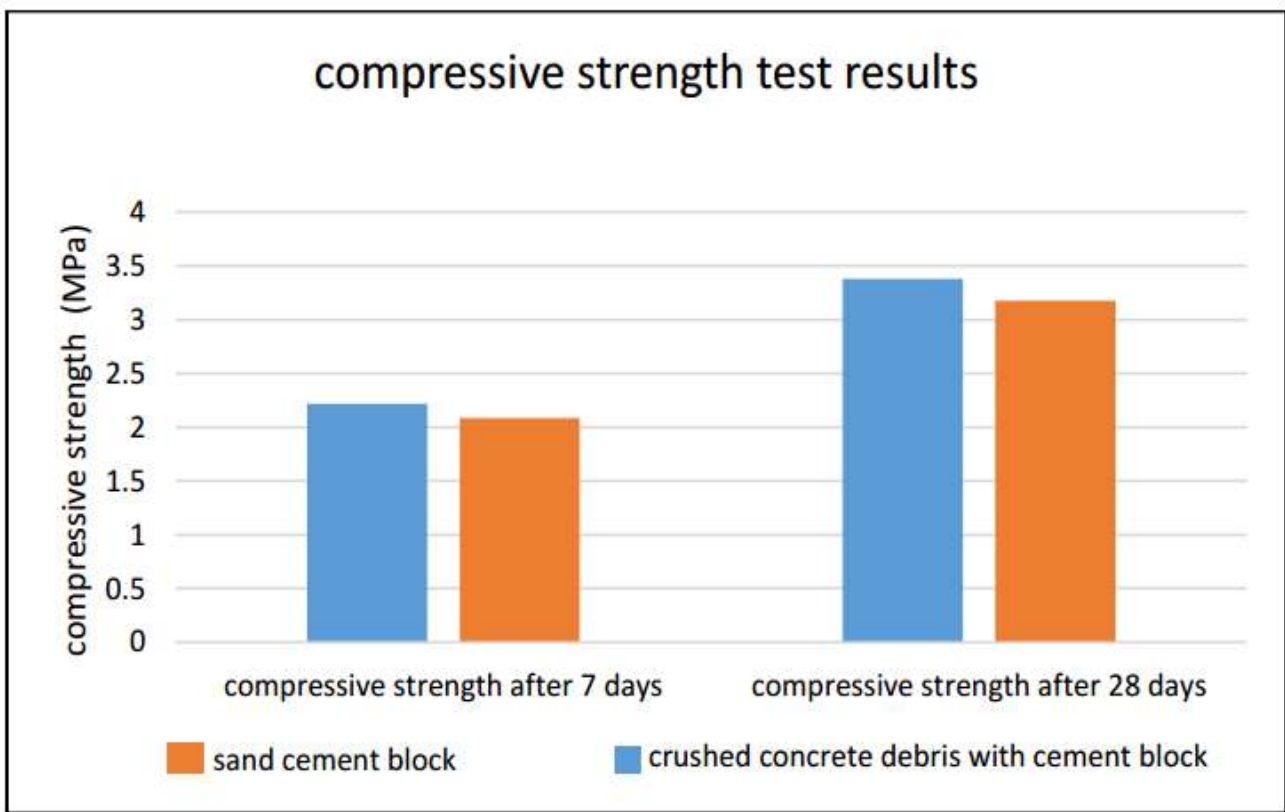
Sieve analysis test result of Cruched concrete debris

Sieve Size (mm)	Weight Retained (g)	Cumulative Weight Retained (%)	Passing (%)
4.75	408	7	93.12
2.36	431	80.65	19.47
1.18	373.5	87.26	12.87
0.600	280	92.26	7.87
0.300	332	97.58	2.54
0.150	100.5	99.14	0.98
0.075	42.5	99.78	0.34
Pan	22.5	100.12	0



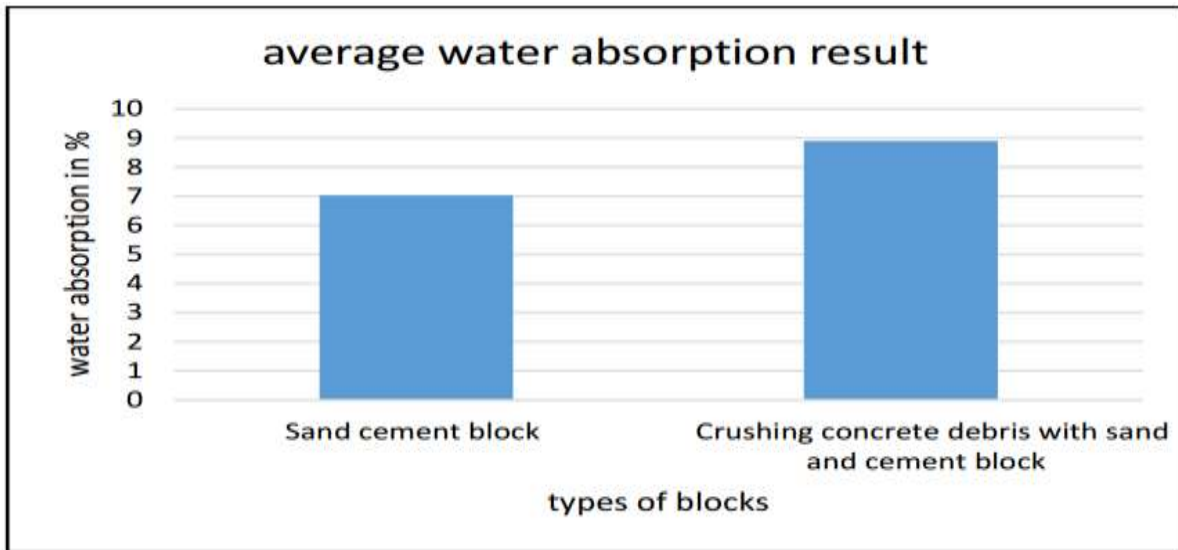
Compressive Strength Test: Blocks were tested for compressive strength after 7 and 28 days.

Block Type	Sample	7-Day Strength (MPa)	28-Day Strength (MPa)
Sand-Cement Block	Sample 1	2.24	5.02
	Sample 2	2.64	4.90
Average		2.44	4.96
Crushed Concrete	Sample 1	3.73	6.35
Debris Block	Sample 2	3.34	6.41
Average		3.54	6.38



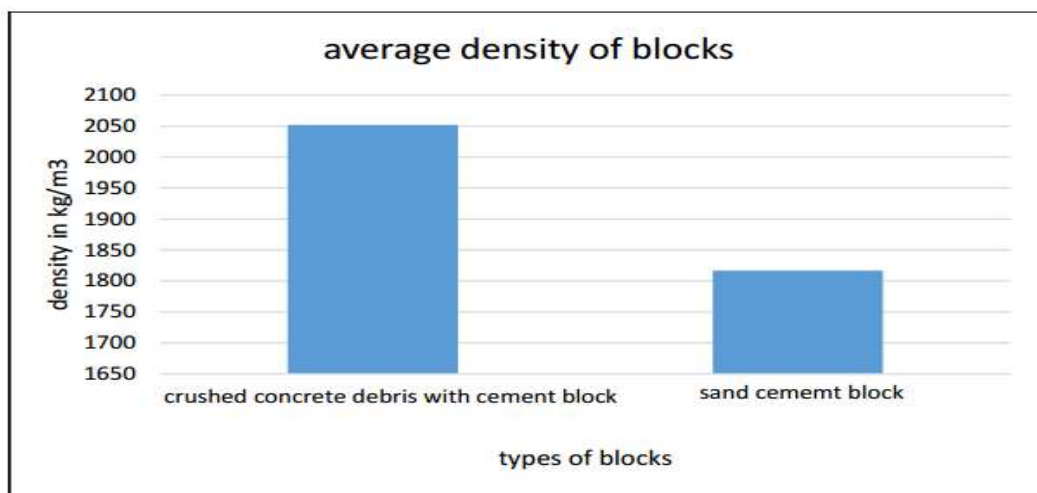
Water Absorption Test: Blocks were immersed in water for 24 hours to measure absorption levels.

Block Type	Sample	Water Absorption (%)
Sand-Cement Block	Sample 1	7.19
	Sample 2	7.16
Average		7.18
Crushed Concrete	Sample 1	6.39
Debris Block	Sample 2	6.44
Average		6.42



Density Test: The density of each block type was calculated based on mass and volume measurements.

Block Type	Sample	Density (g/mm ³)
Sand-Cement Block	Sample 1	0.02125
	Sample 2	0.02128
Average		0.02127
Crushed Concrete debris Block	Sample 1	0.02317
	Sample 2	0.02313
Average		0.02315



4. 2 Results analysis and Discussion

4.2.1 Sieve Analysis

The sieve analysis showed that crushed concrete debris contained a higher proportion of fine particles than sand, suggesting a higher impurity level.

4.2.2 Compressive Strength

The average compressive strength of crushed concrete debris blocks after 28 days was 6.38 MPa, compared to 4.96 MPa for sand-cement blocks. This indicates that recycled debris blocks can bear higher loads and may be suitable for structural applications.

4.2.3 Water Absorption

The average water absorption of crushed concrete debris blocks was 6.42%, lower than the 7.18% observed for sand-cement blocks. This suggests that debris blocks may offer improved resistance to water penetration.

4.2.4 Density

Crushed concrete debris blocks were found to be lighter, with an average density of 0.02315 g/mm³, compared to 0.02127 g/mm³ for sand-cement blocks. This could reduce structural loads in construction.

5. Conclusion

The study concludes that crushed concrete debris blocks provide a viable and sustainable alternative to sand-cement blocks, offering superior compressive strength and comparable water absorption properties. Recycling concrete debris helps promote sustainable construction practices and can reduce costs while maintaining material performance.

6. Recommendations

Construction companies should consider adopting recycled concrete debris blocks for their cost-effectiveness and performance advantages.

Further research is needed to optimize the quality of recycled aggregates by improving crushing techniques.

Government policies should support the adoption of recycled materials through incentives and the development of recycling infrastructure.

7. Limitations

The manual crushing process used in this study may have affected the consistency of the aggregates. The availability of a dedicated concrete crushing machine could improve block performance in future research.

References

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