

Exploring Waste-derived Resources for Concrete Development: Mechanical and Thermal Performance of Coconut Shell Ash Integration

Rodric Luceño ^{*1}, Algen Secula ², Harvey Melendrez ³, Jason Jon Joshua Paraguya ⁴, Arnold Lubguban ⁴, Raymond Virtudazo ², Masayoshi Fuji ⁵

Research Center for Advanced Ceramics (RCAC), Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines¹

Department of Materials and Resources Engineering and Technology, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines²

Resource Processing and Technology Center, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines³

Center for Sustainable Polymers, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines⁴

Advanced Ceramics Research Center, Nagoya Institute of Technology, Tajimi City, 507-0033, Japan⁵

INTRODUCTION AND AIM

The construction industry relies heavily on natural resources such as sand and gravel, leading to environmental concerns and resource depletion. Consequently, there is growing interest in developing sustainable construction materials through utilization of waste-derived resources in cementitious composites. One promising material is Coconut Shell Ash (CSA), a byproduct generated from the combustion of coconut shells used as fuel in various industries. Owing to its fine particle size and porous microstructure, CSA shows potential as a micro-filler material in concrete.

This study aims to evaluate the feasibility of incorporating CSA as a sustainable micro-filler in concrete through the partial replacement of sand at 10% by volume. Specifically, the research investigates the chemical, mechanical, and thermal properties of the resulting concrete composite.

METHODOLOGY



Figure 1. Schematic Diagram of the Study

RESULTS AND DISCUSSIONS

Table 1. XRF Analysis of Coconut Shell Ash

Samples	Oxide compositions (%)											
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	K ₂ O	MnO	ZnO	SrO	SO ₃	MgO	Na ₂ O	CO ₂
CSA110	0.867	0.337	0.277	0.449	0.512	0.007	0.001	0.001	0.065	0.1	0.038	97.8

Coconut shell ash is composed mostly of **Carbon** which can be seen on both the XRF and XRD analyses.

Its specific gravity is 2.67 ± 0.19 g/cc with an average particle size of $76.16 \mu\text{m}$ making it a suitable micro-filler.

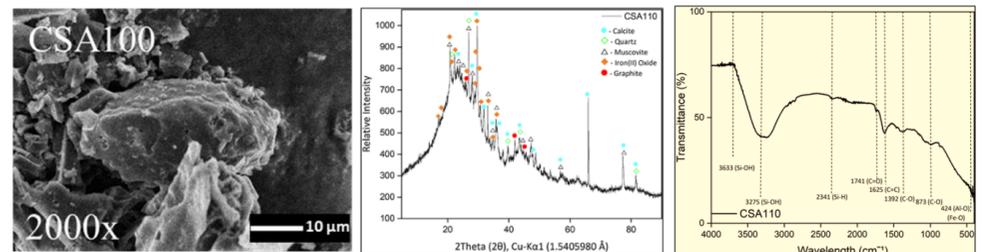


Figure 2. From left to right: SEM of CSA, XRD Analysis of CSA, and FTIR of CSA.

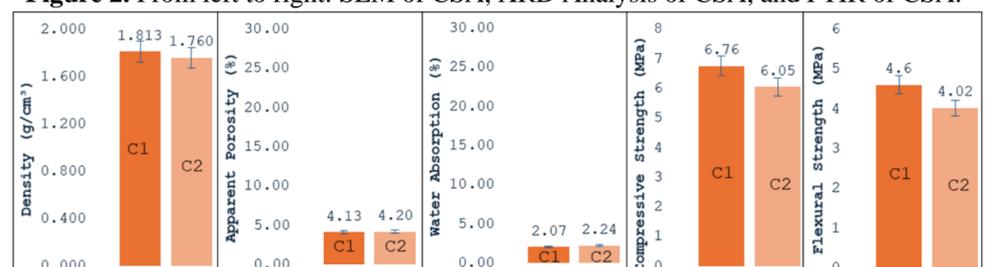
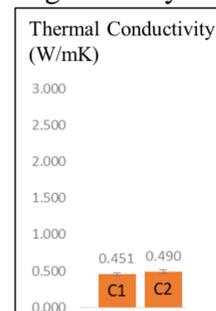


Figure 3. From left to right: Density, Apparent porosity, Water absorption, Compressive strength, and Flexural strength of the cement composites. (C2 is with 10% partial replacement of CSA)

The addition of the CSA as a microfiller reduced the density of the cement composite from **1.813 to 1.760 g/cc**. The water absorption and apparent porosity on the other hand, slightly increased due to the inherent porous property of CSA which can be seen on figure 2 on the SEM image of CSA. The mechanical strength (compressive and flexural strength) decreased significantly.



The Thermal conductivity of the cement composite increased slightly from **0.451 to 0.490 W/mK** with CSA partial replacement to the aggregates. This signifies that CSA is thermal conductive in nature and opens many possible applications.

Figure 4. Thermal conductivity of the cement composites. (C2 is with 10% partial replacement of CSA)

CONCLUSION

The changes in the properties are attributed to the inherent properties of the CSA (lightweight, porous, and thermal conductive). Despite the reduced mechanical performance, CSA demonstrates potential as a sustainable waste-derived material for concrete development.

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