

THERMAL PERFORMANCE OF MICRO CONCRETE ROOFING TILES INCORPORATING WASTE GLASS AGGREGATE: AN EXPERIMENTAL AND NUMERICAL STUDY

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The increasing emphasis on sustainable construction has highlighted the importance of developing alternative building materials that reduce environmental impacts while improving thermal comfort in buildings. Conventional roofing materials such as clay, cement, and asbestos tiles often exhibit poor thermal performance, resulting in elevated indoor temperatures and higher cooling energy demands in tropical climates. At the same time, the accumulation of glass waste presents a significant environmental challenge through its contribution to landfill expansion. While previous research has investigated fly ash, composite roofing materials, and recycled aggregates for thermal insulation, the potential of waste glass as a partial replacement for aggregates in Micro Concrete Roofing (MCR) tiles remains largely unexplored. This study examines the thermal performance of MCR tiles incorporating 5%, 10%, 15%, and 20% waste glass (by weight of fine aggregate) through both experimental testing and numerical modelling.

Waste glass was collected from a local glass manufacturing facility, cleaned, and sieved to ensure consistent particle size. Cylindrical specimens were cast, cured for 28 days, and subsequently subjected to laboratory tests to determine thermal conductivity and specific heat capacity. Thermal conductivity was measured using the Lee's disk apparatus, while specific heat capacity was determined using a calorimetric method. Additionally, a physical model house was constructed to monitor real-time thermal behaviour under natural climatic conditions, and computer simulations were performed using DesignBuilder software, incorporating the experimentally obtained material properties.

Laboratory measurements indicated that increasing the proportion of waste glass enhanced thermal performance, with thermal conductivity decreasing from 0.741 W/mK for conventional MCR tiles to 0.566 W/mK at 15% replacement, while specific heat capacity increased from 833 J/kgK to 927 J/kgK. A physical model house and computer simulations were used to assess real-time and predicted thermal behaviour, showing that roofs with 15% waste glass maintained indoor temperatures approximately 2 °C lower than conventional MCR roofs during peak daytime heat. Numerical simulations further predicted an annual average indoor temperature of 28.67 °C for the 15% waste glass roof, outperforming conventional MCR, clay, and asbestos tiles. The findings suggest that integrating waste glass into MCR tiles can enhance thermal comfort, reduce heat gain, and provide an effective, sustainable means of reusing glass waste in building construction.

Keywords: Energy efficiency, Specific heat capacity, Thermal conductivity, Thermal Simulation

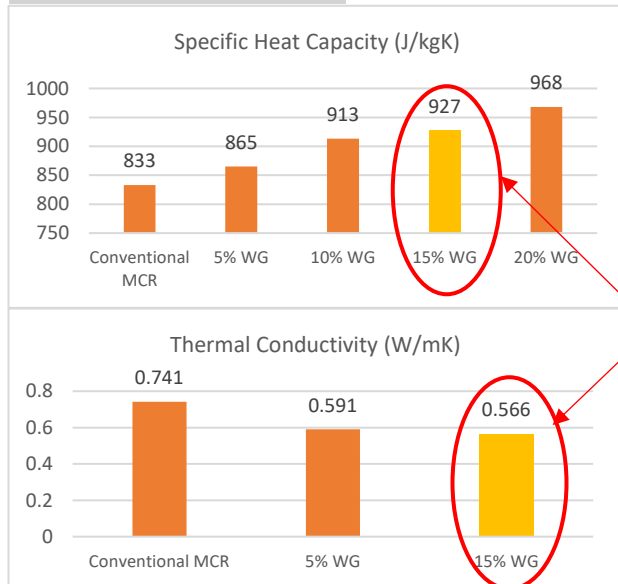
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INTRODUCTION

- Rooftop materials significantly influence indoor thermal comfort, energy consumption, and building sustainability, especially in tropical climates.
- Conventional roofing materials often exhibit high thermal conductivity, resulting in elevated indoor temperatures and increased cooling demand.
- Glass waste is a growing environmental concern, and its potential as a sustainable aggregate in concrete roofing has not been fully explored.

RESULTS AND CONCLUSION



Thermal conductivity decreased and Specific heat capacity increased in 15% WG added MCR

AIM

- To investigate the thermal performance of Micro Concrete Roofing (MCR) tiles incorporating waste glass aggregate and evaluate their potential for enhancing indoor comfort and energy efficiency.

METHODOLOGY

