Development of Sustainable High-Performance Thermal Lightweight Concrete Using Vermiculite, Perlite, and Recycled Marble Waste

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Introduction

- Lightweight concrete (LWC) and high-strength lightweight concrete (HSLWC) are used to reduce structural weight and enhance thermal insulation, meeting energy efficiency and fire safety needs [2].
- Vermiculite and perlite are low-density, porous aggregates that improve thermal and mechanical performance in concrete [1].
- Recycled marble waste serves as a sustainable cementitious material, reducing environmental impact while enhancing concrete durability and strength [3].

Research Aim

To develop innovative, sustainable, high-performance thermal lightweight concrete using vermiculite, perlite, and recycled marble waste

Research Objectives

1. To investigate the impact of perlite and vermiculite combinations as aggregates replacements on the properties of normal concrete.
2. To further improve the optimal vermiculite-perlite-based concrete mixture properties using marble waste as a filler or/and cementitious material.
3. To identify the optimal vermiculite-perlite-marble waste-based concrete mixture (sustainable thermal lightweight concrete) using Response Surface Methodology (RSM).

Methodology

This study investigates three types of concrete: normal concrete (**NC**), vermiculite-perlite-based concrete (**VPBC**), and vermiculite-perlite-marble waste-based concrete (**VPMBC**). The research will be carried out in phases as shown in Fig. 1.

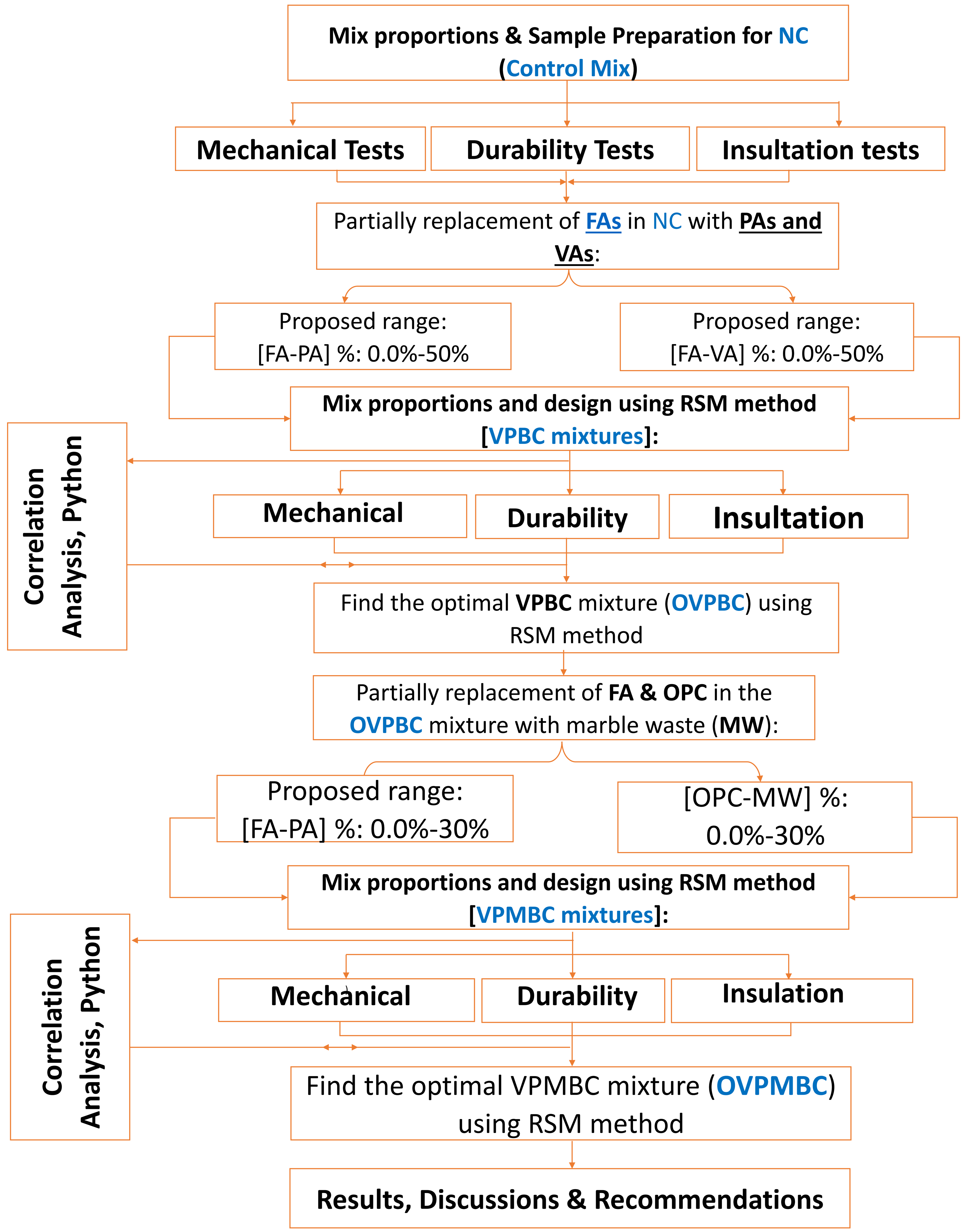

Fig. 1: Research Methodology Flowchart

Expected Outcomes

Table1: VPMBC Properties (Expected)

Property	Expected Results
Compressive Strength	35–45 MPa
Split Tensile Strength	3.0–4.5 MPa
Flexural Strength	5.0–6.5 MPa
Modulus of Elasticity	15–22 GPa
Dry Density	1550–1850 kg/m³
Water Absorption	5–10%
Sorptivity	< 0.25 mm/min$^{0.5}$
Chloride Penetrability	< 2000 Coulombs
Permeability Coefficient	≤ 1×10^{-10} m/s
Thermal Conductivity	0.08–0.15 W/m·K
Thermal Resistance	6–12 m²·K/W
Fire Resistance	900–1100 °C
Shrinkage	< 0.050%

Expected publications

- Publication of 1–2 papers in Q1 peer-reviewed journals.
- Presentation of findings at 1–2 major international conferences.

References

[1] Terzić, A., Stojanović, J., Andrić, L., Miličić, L. and Radojević, Z., 2020. Performance of vermiculite and perlite-based thermal insulation lightweight concretes. Science of Sintering, 52(1), pp. 149-162. https://doi.org/10.2298/SOS2002149T.

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[3] Ulubeyli, G. and Artir, R., 2015. Properties of hardened concrete produced by waste marble powder. World Conference on Technology, Innovation and Entrepreneurship, Social and Behavioral Sciences, 195, pp. 2181-2190. http://creativecommons.org/licenses/by-nc-nd/4.0/.

Property	Expected Value
Compressive Strength	35–45 MPa
Split Tensile Strength	3.0–4.5 MPa
Flexural Strength	5.0–6.5 MPa
Modulus of Elasticity	15–22 GPa
Dry Density	1550–1850 kg/m^3
Water Absorption	5–10%
Sorptivity	< 0.25 $mm/min^{0.5}$
Rapid Chloride Penetrability	< 2000 Coulombs (Moderate)
Permeability Coefficient	$\leq 1 \times 10^{-10}$ m/s
Thermal Conductivity	0.08–0.15 W/m·K
Thermal Resistance	6–12 $m^2 \cdot K/W$
Fire Resistance	900–1100 °C
Shrinkage	< 0.050%