

## The Effects of Partial Replacement with Sewage Sludge, Calcined Clay, and Waste Marble Powder on Cement Paste Properties

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**Abstract :** The cement production process significantly contributes to greenhouse gas emissions, accounting for 25% of total industrial emissions. This study systematically examined new, underutilized materials—sewage sludge ash (SSA), marble waste (MW), and calcined clay (CC)—to evaluate their effects when partially replacing white Portland cement (WPC) in cement paste formulations. Various replacement proportions (10%, 20%, and 30%) were tested, along with different treatment temperatures (600°C, 630°C, 730°C, and 850°C) for SSA and CC. To gain a deeper understanding of the resulting materials, analyses such as XRF, XRD, and SEM were conducted. The highest compressive strength recorded for the 28-day cured cement paste was 91 MPa when 20% SSA (treated at 600°C) was used, compared to just 53 MPa for the control sample. Conversely, CC exhibited minimal enhancement in compressive strength, while MW had detrimental effects. Additionally, replacing WPC with SSA and CC at 9% and 21% resulted in slight improvements in compressive strength. This research highlights the potential of utilizing underexploited materials like SSA to improve the mechanical and chemical properties of cement paste, indicating that further investigation is necessary to enhance environmental sustainability.

**Keywords :** sewage sludge ash, calcined clay, marble waste, cement

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