ABSTRACT

This thesis investigates the hydration kinetics and microstructural development of cementitious systems incorporating natural pozzolans (NPs) and nanosilica (nS), with a focus on both laboratory-prepared paste and mortar samples and field-cast concretes. The research addresses the growing need for sustainable supplementary cementitious materials (SCMs) as alternatives to conventional materials like fly ash amid industry-wide efforts to reduce the carbon footprint of cement production. Experimental studies were conducted to evaluate the performance of two different types of volcanic ashes (VAs) and calcined clay (CC) in concrete systems under varying curing temperatures (5°C, 23°C, and 45°C). Isothermal calorimetry and differential scanning calorimetry were employed to quantify hydration behavior and pozzolanic activity while scanning electron microscopy (SEM) and optical microscopy (OM) were used to characterize the microstructure of concretes after one year of field exposure. The findings demonstrate that NPs can achieve mechanical performance comparable to or exceeding that of fly ash mixtures, with one of the VAs exhibiting particularly favorable results. Additionally, the combination of NPs with nS in ternary systems resulted in slightly accelerated hydration, reduced calcium hydroxide content, and enhanced C-S-H formation, leading to denser matrices. The curing temperature was found to significantly impact hydration kinetics and long-term properties, with low temperatures halting prolonged pozzolanic activity. Overall, this work underscores the potential of NPs to serve as effective, sustainable alternatives in modern concrete infrastructure, offering both environmental benefits and improved material performance.