ABSTRACT

Colloidal nano silica (CNS) has started to gain attention as it forms a three-dimensional floc network in an alkaline environment such as cement pore solution, which allows it to have a unique impact on the performance of concrete materials. The 3D network formed by CNS could slow down the diffusion of moisture and ions within the cementitious system, which impacts the hydration of cement particles, especially at the very early curing period. This change in curing quality and cement hydration further modifies the void structure in concrete, which potentially affects the durability of concrete infrastructure. Currently, there is a lack of in-depth investigation on the impact of CNS on concrete curing, void formation, and its subsequent effect on durability. Therefore, a systematic investigation is necessary to explore the underlying mechanisms and the influence of CNS on cement and concrete materials.

This study investigates the internal curing effects of CNS and its influence on concrete durability. Drying shrinkage, freeze-thaw resistance, bonding quality and carbonation resistance were evaluated. To enhance practical relevance, CNS dosages of 0.3%, 0.6%, and 1.0% were evaluated for their effectiveness in improving concrete performance. The incorporation of CNS significantly increased internal humidity and water retention capacity, resulting in a reduction in drying shrinkage and confirming the effectiveness of internal curing. Additionally, the air void system investigation revealed that CNS increases the total air content in concrete due to its unique air bubble stabilization effect. At the same time, improved cement hydration reduced the average void size, leading to an improved freeze-thaw resistance and superior mechanical strength. Additionally, the formation of a denser cement matrix improves the water impermeability and chloride resistance of the concrete, preventing the ingress of water and other potentially corrosive substances. As a result, the bonding quality between concrete layers was effectively improved with CNS, leading to increased bonding strength and less permeable bonding interface. Furthermore, the carbonation of medium-term concrete was inhibited by the use of CNS, preventing the reduction of pH that could otherwise lead to rebar corrosion. On the other hand, a higher CNS dosage of over 2% led to higher degree of carbonation, suggesting potential applications in carbon sequestration and greenhouse gas reduction.