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Climate Change and Innovations in Concrete Technology

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Extended Abstract

Escalating level of greenhouse gases (GHGs) has contributed to global climate change, among which CO2 is mainly responsible for global warming. Cement industries are responsible for 7-8% of global CO2 emissions during cement manufacturing and operations, which involves calcination of raw material (i.e. limestone) at high temperatures to produce clinker and combustion of fuel. Therefore, for the cement industries globally, CO2-emission mitigation strategies need to be taken into account in their strategic outlook that can help reduce the environmental footprint. In the past, using supplemental cementitious materials (SCMs) to lessen carbon footprints in the construction industry has already been thoroughly investigated. Due to the limited availability of SCMs resources in long term, other innovative ways need to be identified. Recently, carbon capture and utilization is pitched as the encouraging driver that can address the real problem of challenging emissions. CO_2 sequestration in concrete is a promising strategy for lowering carbon footprint and providing a loop for the carbon flow to achieve a more sustainable construction practice. CO_2 sequestration is performed in two ways; First, by injecting CO_2 into ready-mix concrete, and second by enforced curing of prefabricated building components under CO_2 conditions. Both ways have the potential to reduce net emissions by capturing CO_2 and storing it in mineral form (carbonates) in the cementitious matrix. This process can improve the properties of the concrete in addition to capturing CO_2 inside of it.

Accelerated carbonation is a curing mechanism applied to fresh cement-based materials within the first 24 hours after casting. It entails an exothermic chemical reaction between CO_2 and Calcium-containing phases in cement. It has three distinct advantages: i) rapid strength gain ii) improved durability; and iii) permanent carbon dioxide sequestration. Recently, a variety of materials that have the capacity of absorbing CO_2 from the atmosphere is being explored in cement-based materials for CO_2 sequestration such as recycled aggregates and fines, high calcium SCMs, industrial wastes, biomass waste, nano-TiO_2 and carbon-based nanomaterials (graphene, nanoplates, CNTs/CNF). Nanomaterials, in addition to the available SCMs, play a significant role in capturing atmospheric CO2 due to their high reactivity, quantum effects and extended surface areas in contrast to traditional materials. According to earlier research, nanomaterials have the potential to modify the shape of hydration products, especially calcium hydroxide (CH), and can significantly hinder the formation of hexagonal lamellar crystals and refine the size of the CH crystals

In our research, we observed that, in addition to improving the mechanical and hydration properties of cement-based materials, graphene oxides (GO) also have the ability to absorb atmospheric CO_2 and permanently store it in the cement matrix as calcium carbonates. The ability of cement composites to absorb CO_2 was improved by 30% by the addition of relatively small amounts (between 0.05 and 0.1%) of graphene oxide nanosheets.