Influence of MWCNTs on portlandite Ca(OH)2 hydrates in MWCNT – reinforced concrete

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Abstract

Purpose – The aim of this research is to study the role and formation of hydration products particularly crystalline portlandite Ca(OH)2 in MWCNT-reinforced concrete at 28 days. Concrete is the largest manufactured building material in world in which cement, sand aggregates and water cement ratio plays governing role. Water–Cement ratio decides it strength, usage, serviceability and durability. As strength of concrete depends on formation of crystalline hydrates; therefore, water–cement ratio can alter formation of hydrates also. Unfortunately, concrete is the most brittle material and to overcome brittleness of conventional concrete is tailored with some fibers. Till now, multiwalled carbon nano tubes are the most tensile and strongest materials discovered. Addition of multiwalled carbon nano tubes changes basic properties of conventional concrete. Therefore, it is important to evaluate formation of crystalline hydrates in multiwalled carbon nano tube–reinforced concrete by micro structure analysis.

Design/methodology/approach – Till now, multiwalled carbon nano tube–reinforced concrete has not been analyzed at micro structure level. To accomplish the objective, four concrete mixes with 0.45, 0.48, 0.50 and 0.55 water–cement ratio having 0.5 and 1% multiwalled carbon nano tubes incorporated by weight of cement, respectively. For hardening property analysis, compressive strength was obtained by crushing cubes; flexural strength was obtained by three-point loading; and split tensile strength was obtained by splitting cylindrical specimens. For analyzing role and formation of crystalline portlandite Ca(OH)2 hydrates, X-ray diffraction test was conducted on 75-μ dust of each mix. Scanning electron microscopy analysis was performed on fractured samples of crushed cubes of multiwalled carbon nano tube–reinforced concrete samples to check aggloremation.

Findings – It was observed multiwalled carbon nano tubes successfully enhanced compressive strength, flexural strength and split tensile strength by 8.89, 5.33 and 28.90%, respectively, in comparison to reference concrete at 0.45 water–cement ratio and 0.5% multiwalled carbon nano tubes by weight of cement. When its content was increased from 0.5 to 1% by weight of cement compressive strength, flexural strength and split tensile strength diminished by 2.04, 0.32 and 1.18%, respectively, at 0.45 water–cement ratio. With the increment of water–cement ratio, overall strength decreased in all mixes, but in multiwalled carbon nano tube–reinforced concrete mixes, strength was more than reference mixes. In reference, concrete at 0.45 water–cement ratio crystalline portlandite Ca(OH)2 crystals are of nano metre size, but in carbon nano tube–reinforced concrete mix having 0.45 water–cement ratio and 0.5% multiwalled carbon nano tubes by weight of cement, its size is much smaller than reference mix, thereby enhancing mechanical strength. In reference, concrete at 0.55 water–cement ratio size of crystalline portladite Ca(OH)2 crystals is large, but with incorporation of multiwalled carbon nano tubes, their size reduced, thereby enhancing mechanical strength of carbon nano tube–reinforced concrete having 0.55 water–cement ratio and 0.5 and 1% multiwalled carbon nano tubes by weight of cement, respectively. Also at 1% multiwalled carbon nano tubes by weight of cement, agglomeration and reduction in formation of crystalline portlandite Ca(OH)2 crystals were observed. Multiwalled carbon nano tubes effectively refine pores and restrict propagation of micro cracks and act as nucleation sites for Calcium-Silicate-Hydrate phase. Geometry of crystalline axis of fracture for portlandite Ca(OH)2 crystals is altered with incorporation of multiwalled carbon nano tubes. Crystalline portlandite Ca(OH)2 crystals and bridging effect of multiwalled carbon nano tubes is governing factor for enhancing strength of multiwalled carbon nano tube reinforced concrete.

Practical implications – Multiwalled carbon nano tube–reinforced concrete can be used to make strain sensing concrete.

Originality/value – Change in geometry and size of axis of fracture of crystalline portladite Ca(OH)2 crystals with incorporation of multiwalled carbon nano tubes.

Keywords Concrete, X-ray diffraction, Compressive strength, Flexural strength, Multiwalled carbon nano tubes, Portlanlite

Paper type Research paper

Abbreviations

Weight by cement (wbc);
Reference Concrete (REF);
Multiwalled Carbon Nano Tubes (MWCNTs);
Carbon Nano Tube–reinforced Concrete (CNTC); and
Water–Cement Ratio (W/C).

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