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# EFFECT OF ADDING POLAR IMPURITIES ON CARBON NANOTUBES AND CONCRETE BONDING STRENGTH

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**Summary:** Concrete is one of the most widely used and economical materials of construction. Concrete is a multi-phase composite material that is known to age over time. Improving its performance has been a major goal for many researchers. A relatively new field of study is the use of nanoparticles in concrete to improve its workability, durability and strength in addition to adding new functionalities. The outstanding mechanical properties of carbon nanotubes (CNTs) highlight them as potential candidates for concrete reinforcement. The strength of the CNTs is directly related to the strong C=C bond and the relatively small number of defects present in the tubes. It is said to possess "a hundred times the strength of steel at one sixth of the weight" (Kelsall et al 2006). The CNT are characterized by thermal stability up to 2800 0C (Cwirzen 2009). However, their surfaces have very low friction, so it is very difficult for them to bind together or with the cement matrix material (Scrivener and Kirkpatrick 2008). In addition, carbon nanotubes are packed together by Van der Waals attraction forces into crystalline ropes during production. These ropes tend to aggregate and result in lack of ability of CNT powder to disperse in aqueous or organic solutions (Cwirzen 2009). Incorporating the unique mechanical properties of CNTs in cement composites is complex, and results vary between studies. One way to increase the solubility of CNTs in water is through the addition of polar impurities such as OH or COOH end groups. This research experimentally investigates the effect of adding polar impurities to even the dispersion of carbon nanotubes in the cement matrix and examining its influence on concrete strength for the same cement to water ratio. The cementitious material used in the study was composed of Portland cement, crushed rocks and natural sand. A control mix was prepared using 0% CNTs, while other mixes contained varying percentages of CNTs, and CNTs with polar OH and COOH impurities. Concrete samples in the form of cubes of 5cm sides were prepared and cured for three different time periods (7, 14, 56 days). The concrete samples were tested for compressive strength and modulus of elasticity, and physically characterized based on the extent of CNTs' dispersion and the concrete workability. Microstructure examination using a scanning electron microscope (SEM) was performed on CNTs added to the concrete mix, as well as the crushed specimens. The degree of dispersion and interaction between concrete and nanotubes with polar impurities was also determined. Molecular Dynamics (MD) models using NAMD scalable molecular dynamics software was used to develop and fully understand the behavior of the nanoparticles with the cement.

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