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The effect of water cement ratio on the characteristics of multi-walled carbon nanotube reinforced concrete

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ABSTRACT

Water Cement ratio play vital role in strength, durability and serviceability of concrete. In this study effect of water-cement ratio on the strength of multi walled carbon nano tube reinforced concrete is analyzed. Five concrete mixtures at different water-cement ratio (W/C) with and without carbon nano tubes (CNTs) were prepared. W/C of 0.40, 0.45, 0.48, 0.50 and 0.55 were used while quantity of carbon nano tube (CNT) was fixed at 1% by weight of cement (wbc). The workability of carbon nanotube reinforced concrete (CNTC) by was reduced by 39.57% while W/C = 0.48 was found ideal for slump as well as strength. At this W/C compressive strength for CNTC increased by 7.14%.

1. Introduction

Functionalities of concrete improved with addition of nano materials. Incorporation of nano materials in concrete with advancement in nano technology resulted in nano modified concrete. Nano material, such as Carbon Nano Tubes (CNTs) has potential to modify mechanical properties of concrete.

Carbon nanotubes are byproduct of the fullerene synthesis discovered in 1991 at the NEC Fundamental Research Laboratory in Japan [1]. Graphite sheets are made of tubes such as zigzag, chiral, and armchair that can form a single-walled or multi-walled nanotube, but remain as a hollow cylinder [2,3]. They have excellent mechanical properties with Youngś modulus upto 1 TPa, tensile strength approximately 100 GPa and fracture at a stain up to 15%. CNT have a high specific surface area with a value of up to 1000 m^2g^{-1} [4,5,6]. They also show very high thermal conductivity of 1700–3000 W/mk and very low electrical resistivity of 5×10^{-8}–2×10^{-6} Ωm, similar to copper [7]. CNTs exhibit a low density even at high aspect ratio. They provide large interfacial contact area in matrix with- out much weight penalty like conventional fibers, hence reinforce concrete more efficiently [8,9,10]. They potentially restrain the propagation of small nano cracks and prevent crack initiation [11,12]. Basic properties CNTs have shown growing interest for the development of smart concrete. Due to high surface area and strong van der wall force between CNT bundles they tend to agglomerate [13,14]. Therefore, the dispersion of CNTs play vital role for effective and innovative functionalities. For effective dispersion mechanical as well as chemical methods are employed. Mechanical methods involves ultra sonication, magnetic stirring, and even hand mixing, while chemical methods involves use of surfactants and functionalization [15]. But no proper method to guarantee full dispersion is reported [15]. At 0.4, 0.5 and 0.6 W/C Kim et al. [16] observed decrease in workability of mortar mixtures when 0.1%, 0.3% and 0.5% MWCNTs, by weight of cement was incorporated to them. Similarly at 0.5 W/C Collins et al. [17] observed reduction of 14.5%, 32.8%, and 48.9% in slump diameter with 0.5%, 1%, and 2% addition of MWCNTs respectively. When Maker and chan [18] added 1% of SWCNTs by weight to cement they observed acceleration of hydration reaction of the C3S and change in morphology of C3A. Hydration reaction rate increased as CNTs act as nucleation sites for hydration products. Not only SWCNTs increases hydration rate but MWCNTs also increases hydration rate of cement as observed by Cui et al. [19]. They also reported hydration of cement accelerates with increasing MWCNTs content.

When Bharj et al. [20] added 0.1% MWCNTs, by weight, to concretes, and observed increment of 7, 14, 28 and 35 days compressive strength. 90 days compressive strength of was also enhanced by Hamzaoui et al. [21] with addition of 0.003% CNTs by weight to concretes. Tonder and Mafokoane [22] reported that at 28 days compressive strength increased by 13%, 20%, and 9%, while tensile

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