Amelioration of freeze thaw damage of concrete with multi-walled carbon nano tubes

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Abstract

Purpose – In cold areas, frost damage is the main factor for diminution of durability and serviceability of structures. Due to incessant freeze thaw regimes, micro cracks spread and deteriorate concrete to point of failure.

Design/methodology/approach – The study aims to evaluate the fresh and hardened properties of concrete after thirty freeze-thaw cycles tailored with carbon nano tubes. For this purpose, samples with 0.4, 0.45, 0.48, 0.5 and 0.55 water cement ratio while 0.5 and 1% carbon nano tube (CNT) content by weight of cement were prepared.

Findings – At 0.48 water cement ratio and 0.5% CNT by weight of cement workability reduced by 37% and water absorption reduced by 0.04%. But compressive strength, split tensile strength and flexural strength increased by 15.38, 33.02 and 15.75%, respectively, after 30 freeze thaw cycles. Also, weight loss reduced with addition of 0.5% CNT by weight of cement after freeze thaw cycles.

Originality/value – Novelty of this research is to tailor traditional concrete with new materials.

Keywords Compressive strength, Concrete, Freeze-thaw, Flexural strength, Multi-walled carbon nano tubes, Split tensile strength, Water-cement ratio, Workability, Weight loss

Paper type Research paper

Abbreviations

wbc = Weight by cement;
REF = Reference Concrete;
MWCNTs = Multi Walled Carbon Nano Tubes;
CNTC = Carbon Nano Tube reinforced Concrete;
W/C = Water-Cement Ratio; and
FT = Freeze Thaw.

1. Introduction

Construction industry plays profitable role in every economy. It obliterates huge proportions of available resources to construct infrastructures. Cement is the main ingredient of concrete along with fine and coarse aggregates. Durability and serviceability of structures plays a governing role in the life span of concrete structures. Normally, frost damage is the main factor for diminution of durability and serviceability of structures in cold areas where incessant freezing and thawing regimes lead micro cracks to spread and deteriorate concrete to the point of failure. According to Litvan (1972), the water does not freeze in capillary pores *in situ*, but when the temperature sinks below 0°C, water gets super cooled and travels to a surface where it freezes and desiccate specimen. If the concentration of water is much higher than requirement, desorption process occurs. This desorption process is facilitated by air voids because they reduce travelling distance to freezing surface. Thereby, more water leaves pores and specimen is protected (Litvan, 1972). Frost resistance of the concrete can be achieved by refining of pores and by transforming larger voids into evenly distributed and smaller voids (Ebrahimi *et al.*, 2018).

With advancement nano-sized fibers, such as carbon nanotube (CNT), concrete can be tailored with them. So far, CNT is the strongest material known; it is believed to be an ideal reinforcement for concrete (Makar and Beaudoin, 2003). CNTs have potential to modify mechanical properties of concrete and improve its durability. They possess outstanding mechanical properties with Young's modulus upto 1 TPa, tensile strength approximately 100 GPa and fracture at a strain up to 15%. They have a high-specific surface area with a value of up to 1000 m^2g^{-1} (Iijima, 1991; Esawi and Farag, 2007). They provide large interfacial contact area in cement-based composites without much weight penalty like traditional fibers, and reinforce concrete more efficiently (Dalton *et al.*, 2003; Wang *et al.*, 2008; Dikshit *et al.*, 2008). CNTs accelerate hydration of cement products as they act as nucleation sites for growth of Calcium-Silicate-Hydrate (C-S-H) gel (Parveen *et al.*, 2013) .They efficiently restrain the propagation of nano cracks and prevent crack initiation (Konsta-Gdoutos *et al.*, 2010; Hu *et al.*, 2014).

As CNTs act as fillers, nucleation sites for growth of C-S-H, and provide bridging effect in cement-based composites, thereby strengthening concrete. Even though concentration of pore size and bridging effect improves with CNT, total volume of pores of a specimen remains unchanged as concentration of macro pores remain unchanged (Nochaiya and Chaipanich, 2011).

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