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Evaluating the Effects of Carbon Fiber on Mechanical Properties and Durability of Concrete

Sayyed alirezazareei[1], Arash sedaghat doost[2], Farhad ansari[2]

1-Department of civil engineering, Khorasgan(Isfahan) Branch, Islamic Azad University, Isfahan,Iran
2-Graduate student of civil engineering, Khorasgan(Isfahan) Branch, Islamic Azad University, Isfahan,Iran
A.R.Zareei@khuisf.ac.ir

Abstract

Concrete is one of the most widely used construction materials which has both advantages and disadvantages. One of the disadvantages of concrete is its very low tensile strength leading to a sudden collapse and failure of concrete structures. The brittle concrete can be reinforced by steel reinforcement applied in the direction of tensile forces. However, in many cases, the direction of these forces is not exactly known. Therefore, the need to high tensile strength and high-energy absorption concrete has been the reason for using fiber concretes in the past decade. Fiber concretes are commonly produced by adding fibers to concrete mixture, as a reinforcement material, to enhance cohesion, tensile strength and crack propagation control in the elements of reinforced concrete; furthermore, it improves the energy absorption potential.

In this paper, the mechanical properties of concrete with carbon fiber are investigated. Fibers were added in different percent, 0%, 0.5%, 1%, and 1.5%, proportional to cement weight. All the samples were made from the same water-cement ratio. The produced samples were tested for compressive, flexural, tensile strength, impact test and water absorption at the age of 28 days. As it can be seen from the results, with the increase in the amount of fibers, the strength properties of concrete improves as well.

Keywords: Concrete, Carbon fibers, Mechanical properties, Durability.

1. INTRODUCTION

Huge costs are wasted every year due to the corrosion of the reinforcing steel and broken concrete. Consequently, the use of non-metallic fibers in concrete will, to some extent, reduce plastic cracks and loss and creep cracks in concrete and neutralize the effect of alkaline environments on fibers to prevent the capital loss. This is because the fibers have randomly been spread in different directions in concrete; therefore, they reinforce the mechanical properties of concrete. By creating sufficient adhesion between the fibers and the concrete matrix, the fiber in concrete improves the structure of properties such as increasing in tensile and compressive strength, impact resistance, thermal shocks resistance and the detachment after the shock, resistance to fatigue, and improvement in the crack parameters and deformation which in all increase the toughness and durability of concrete. To differently put, the existence of fibers in concrete in three directions improve the durability and toughness of concrete. It should be noted that the ability of the fibrous concrete has a direct relation with mixing and concrete properties, physical properties of fibers, fiber type, fiber spread in concrete and go togetherness of fibers on the one hand and geometrical properties of fibers like fibers' length to diameter, roughness of fiber surface and the direction of fibers in concrete on the other.

Park & Kim [1] studied flexural and tensile strength of light concretes using different forms of carbon fiber and found that the shape and form of the fibers influence strength. Azhari [2] stated that carbon fibers and carbon nano-tubes significantly increase electrical conductivity of cementitious materials. Deng [3] found that the total value of dissipated energy during the flexure-fatigue/break test for the concrete reinforced with carbon fiber is 9.6 to 13.7 times larger than that of a plain concrete. Giner [4] mentioned that carbon fiber concretes are more effective than concretes containing silica in reducing vibrations under dynamic loads with high frequency. Shigeyuki Akihama [5] stated that by adding three to five percent carbon fiber to cement, we can attain a great plasticity and hard composites with a tensile strength of 80 to 140 kg/cm2; moreover, a tensile strain of 1100×10-6 can be attained as well.