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MECHANICAL AND FRACTURE PROPERTIES OF CARBON FIBER REINFORCED SELF-COMPACTING CONCRETE COMPOSITES

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Summary: Concrete alone as a composite material is a relatively brittle material. Reinforcement of concrete with randomly distributed short fibers may enhance the toughness of cementitious matrices by preventing or controlling the initiation, propagation, or coalescence of cracks. Among fibers, carbon fibers are very attractive to engineers due to their good thermal conductivity, lightweight, and high modulus of elasticity. Many studies have been conducted since 1970s to investigate the effectiveness of carbon fibers on the various properties of conventional concrete. However, the studies dealing with the application of carbon fibers in self-compacting concrete (SCC) are very limited in the technical literature.

This study covers the effect of using carbon fiber on the mechanical and fracture properties of SCC composites. A total of 8 SCC mixtures with and without ultra-fine silica fume were designed with a total binder content of 530 kg/m3 and water-to-binder ratio of 0.37. Carbon fiber with 7.2 μm diameter and 12 mm length was utilized in SCC mixtures by considering four fractions of 0, 0.5, 1.0, and 1.5% by total concrete volume. Carbon fiber used in this study had a tensile strength of 3800 MPa and modulus of elasticity of 228 GPa. To achieve the same homogeneity and uniformity in all mixtures, a special batching and mixing procedure was followed since mixing sequence and duration are very vital in SCC production. Plain and carbon fiber reinforced SCC specimens were tested for determining the mechanical and fracture properties. The mechanical properties of SCCs were carried out in terms of compressive strength, modulus of elasticity, splitting tensile and net flexural strengths while the fracture characteristic were evaluated in terms of fracture energy and characteristic length. Compressive strength of the mixtures was determined on 150-mm cubic specimens. Static modulus of elasticity was determined on 150-mm cylinder specimens. Splitting tensile strength test was performed on 100-mm cylinder specimens. Fracture energy was determined on 100x100x500-mm beam specimens by using a closed-loop testing machine with a capacity of 250 kN. Notch to depth ratio (a/D) of the beam specimens was 0.4 and the notch opened by sawing to accommodate large aggregates in more abundance reduced the effective cross section to 60x100 mm. Distance between supports was 400 mm and midspan deflection (δ) was measured by a linear variable displacement transducer (LVDT). Load versus deflection curve was obtained for each specimen and area under load versus deflection curve (Wo) was used in determination of the fracture energy. Test beams were loaded at a constant rate of 0.02 mm/min. The fracture energy was calculated by using the part of the area under load versus deflection curve up to specified deflection of 1.5 mm. Notched beams were used to calculate the net flexural strength. The characteristic length, which is the indication of brittleness of the mixtures, was also calculated. Test results indicated that incorporating carbon fiber into the matrix enhanced strength and especially fracture characteristics of SCCs, depending mainly upon carbon fiber content.