Effects of Micro/Nano-SiO_2 on Fresh Properties, Compressive Strength and Segregation Resistance of Self-Consolidating Lightweight Concrete

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Abstract:

This paper reports the effects of Nano Silica (NS) and Silica Fume (SF) on the rheology, compressive strength and aggregate segregation of Self Consolidating Lightweight Concretes (SCLC). Totally, sixteen concrete mixtures are prepared containing different amounts of SF and NS as 0%, 2%, 4% and 6% (by weight of cement) with water/binder (W/B) ratios of 0.44. Fresh properties of concretes were determined through Visual Stability Index (VSI), slump-flow time and diameter and V-funnel flow time (T0min and T5min) tests. In addition, the uniformity of distribution of LWAs along the specimen is also evaluated by the column segregation test and the cross-section image. The results showed that the fresh properties of SCLC improved significantly for the specimens containing micro and Nano silica. The results indicate that the mixtures containing NS and SF have higher viscosity than the control mixture. Furthermore, although in some specimens the compressive strength of the concrete mixtures had slightly increase, aggregate segregation and uniformity of distribution of LWAs were enhanced by using silica, especially in Nano scale.

Keywords: Self-Consolidating Lightweight Concrete, Rheological Properties, Compressive Strength, Segregation Resistance, Silica fume, Nano-SiO2.

1. INTRODUCTION

Up to now, researches performed over the years have been largely aimed at achieving high mechanical performance with cement replacement materials in micro size [1-3]. Recently, Nano technology has attracted considerable scientific interest due to the new potential uses of particles in nanometer scale. A nanometer (nm) is one billionth of a meter. The devices and materials dealt with in nanotechnology are typically in a size range of 0.1 nm to 100 nm. Nanotechnology is referred to the science and technology of developing materials at the atomic and molecular level and generating techniques in order to measure and utilize their unique and special mechanical and chemical features [4-7]. Silica nanoparticles, due to their high pozzolanic reactions and also making a denser microstructure, can modify the properties of concrete.

Several authors have investigated the effect of Nano silica in cementitious materials. Generally, The results show that Nano silica accelerate the chemical reactions during initial hydration [8-10]. Qing et al. [11] studied the effect of Nano silica on the properties of cement pastes where they conducted several tests such as compressive strength and setting time tests. They indicated that the influence of Nano silica and silica fume is different since Nano silica makes cement pastes thicker and also accelerates the hydration process. In addition, they showed that bond strengths of paste–aggregate interface incorporating NS are higher than those of control sample and also higher than those incorporating SF. With increasing the NS content, the rate of bond strength increase is more than that of their compressive strength increase.

Despite all advantages associated with the use of concrete in infrastructures, its high self- weight compared to other construction materials, almost make it inadequate because of increasing their risk due to earthquake acceleration [12]. In addition, the properties of light weight aggregate concrete (LWAC) include heat insulation, sound absorption, ease of use and reducing the areas of sectional members as well as making the construction convenient [13-19]. Thus, the construction cost can be saved when applied to structures such as long span bridge and high rise buildings [20]. It has been successfully used in buildings where soil conditions are poor, to highly specialized structures such as floating structures and offshore platforms [21].

Vibration of lightweight concrete tends to be less efficient because the lightweight coarse aggregates move the upward and form a weak layer [22-26]. Thus, Noticeable handicap of LWAC is segregation of