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Properties of Sustainable Cement Mortars Containing High Volume of Raw Diatomite

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ABSTRACT

This paper presents the results of a study on properties of cement mortars containing high volume of raw diatomite powder as replacement of cement. The use of high volume of pozzolanic powders decreases the demand for cement in the construction industry and thus reduces the cost of concrete production and lessens the environmental pollution caused by the co2 emission from the cement factories. The aim of this study is to investigate key properties of environmental-friendly cement mortars using raw diatomite powder as replacement of cement in different contents. In this study, cement mortars containing four different contents of raw diatomite powder as replacement of cement (0, 15, 30 and 40 by weight of total cementitious material) are examined. The flowability of cement mortars was observed through flow table test. The compressive strength and direct tensile strength were measured at 3, 7, 28 and 91 days as strength properties. Water absorption and pulse velocity tests were investigated for various cement mortar mixtures at 28 days as transport properties and durability indexes. An environmental impact assessment was also applied on all cement mortar mixes based on eco-balance method to quantify and evaluate the environmental impact of partially replacing cement by raw diatomite powder. Test results indicated that diatomite powder can be used as replacement of cement up to 40% without significant loss in compressive strength along with an improvement in tensile strength and transport properties of cement mortars, at the later aging times. The experimental results on strength and transport properties represent a very effective and successful use of high volume raw diatomite powder to produce an environmental-friendly and affordable cement-based material. Sustainability assessment shows a significant reduction in environmental impact of mortars containing high volume of raw diatomite powder.

Keywords: *Raw diatomite powder, Cement mortars, Strength properties, Transport properties, Environmental impact*

1. Introduction

Concrete is the most widely used construction material, commonly made by mixing Portland cement with aggregates and water [1]. According to the amount of cement produced in 2007, it can be estimated that concrete consumes about 2.5 billion tons of cement, 1 billion tons of mixing water and 10 billion tons of aggregates annually [2]. On the other hand, each ton of Portland cement that is produced involves the release in to the atmosphere of about one ton of co_2. Indeed, the cement industry is responsible for about 7% of global co_2 emissions [1]. The use of high volume of pozzolanic powders decreases the demand for cement in the construction industry and thus reduces the cost of concrete production and lessens the environmental pollution caused by the co_2 emission from the cement factories [3].

Diatomite is a sedimentary rock containing fine and amorphous silica particles that are created due to accumulation of shells or skeletons of fossilized algae and microscopic particles called diatoms [4]. The amorphous silica (opal-A) is mainly in the form of diatom frustules, and secondarily in the form of sponge spicules, silicone- flagellate skeletons and/or radiolarian cells. Beside opal-A, the diatomite rocks commonly contain carbonate and clay minerals, quartz, feldspar and volcanic glass [5]. Diatomite is used in its natural state and in the form of various fire articles. Ground diatomite is used to fill covers, furnace domes, pipe insulation and for insulating walls. The main applications of diatomite in the world are as filtering materials and sorbents. Diatomite has diverse applications because of its unique pore structure. It is most widely used throughout the world as filtration material, sorbents, fillers and insulation material. Diatomite is promising for the preparation of nano composites, for example, for filling nonporous with various substances [6]. Diatomite can also be used as pozzolanic powder in cement–based materials. Kastis et al. conducted a study on properties and hydration of blended cements with calcareous diatomite. Results from their study present the used diatomite as natural pozzolanic material considering the active silica content. It was also reported that the pozzolanic reaction of diatomite resulted to the formation of higher amounts of hydrated products, especially at higher ages [5]. Fragoulis et al. studied the physical and mechanical properties of composite cements manufactured with calcareous and clayey diatomite mixtures. Their research concluded that the combination of higher reactive silica content and higher Blaine fineness of diatomite powder results in cements with improved mechanical properties [7]. Degirmenci and Yilmaz published a study on the use of diatomite as partial replacement for Portland cement in cement mortars. Their results revealed that sulfate resistance of the mortars containing diatomite powder was higher than that of the control mortar. It was also reported that the water absorption of mortars decreased with the increase of diatomite content in most mixtures [8]. Yilmaz and Ediz investigated the use of raw and calcined diatomite in cement production. Results from their study showed that raw diatomite blended cements produced comparable strength values with respect to the reference cement up to 10% addition. They also mentioned that calcinations changed the porous structures of diatomite and eased the grind ability as well as providing it to be used as a cement addition at a higher rate of 20% [9]. Krajci et al. evaluated the properties of ternary cement composites containing calcined clayey diatomite and metakaolin sand, their research concluded that