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Review

Effect of gamma irradiation on polymer modified white sand cement mortar composites

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ABSTRACT

This study focuses on the substitution effect of standard sand of cement mortar by different ratios of white sand to prepare white sand cement mortar. The prepared samples were first cured under tap water for different time intervals 3, 7, 28 and 90 days. The effect of addition of 10% styrene–acrylic ester as well as the effect of different doses of gamma rays on the physico-mechanical properties of polymer modified white sand cement mortar specimens also, discussed. Compression strength test, total porosity and water absorption percentages were measured. The results were confirmed by scanning electron microscopy, and thermogravimetric analysis studies.

Contents

1. Introduction

Sinai is considered one of the most important areas in Egypt containing white sand; white sand reserve of Sinai is about 27 million tons. It contains high silica content (98.8%). It is consumed in large number of industries in different forms such as glass, synthetic foundry molding catalysis and solar cell industry. Also, white sand attracted the attention of several researchers to use it as a substituent of ordinary sand in the production of cement mortar and concrete. The effect of different ratios of white sand 5%, 10% and 20% on the physic-mechanical properties of blended cement pastes was studied. The results indicated that A pronounced increase of the compressive strength values were observed for the hardened blended cement pastes with different white sand ratios at different hydration time intervals 3, 7, 14, 28 and 90 days comparing to the hardened neat Portland cement (OPC) pastes. While, the cumulative pore volume becomes much smaller as the percent of white sand increases in the prepared blended cement pastes [1]. In addition, the cumulative leach fraction (CLF) for ^{137}Cs and ^{60}Co radioactive ions from the hardened

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blended cement white sand pastes after 90 days were measured. The examination of the leaching data revealed that adding white sand to cement reduces the leach pattern as OPC + 5% white sand < OPC + 10% white sand < OPC + 20% white sand < OPC only for the studied radionuclides.

Recent years interest in environmentally friendly concrete (EFC) has been increased, which utilize the industrial byproducts or waste materials and thus benefit the environment. Among them, mineral admixtures such as fly ash, silica fume, and slag and other, have been used to partially replace cement in concrete [2,3]. An ordinary cement system offers relatively low durability properties as a result of ease of the initiation and propagation of micro-cracks and also the lack tensile resistance of conventional cement mortars [4]. Furthermore, it has been emphasized that the durability characteristics of the cement system can be greatly improved by reducing permeability of the materials [5,6]. Accordingly, the permeability of concrete plays a critical role in controlling the properties of concrete and its serviceability. Recent advances in the field of cement products are related to the use of admixtures specially those of organic materials like polymers added in small quantities to modify the properties of cement products.

In modern concrete construction, the composites made by using polymer along with cement and aggregates are called polymer-modified concrete (PMC), while composites made with polymer and aggregates are called polymer mortar (PM) or polymer concrete (PC). In this regards, the performance of cementitious materials can be improved by the addition of particles that are small enough to fill the gaps between cement particles [7]. Polymers have been used as additives and modifiers for cement and cement based materials, such as mortar and concrete. The property improvement of mortar and concrete by polymer modification was related to; the incorporation of polymer on the material structures, cement hydration, porosity and unit water content. As well as to the chemical and physical interactions between polymers and cement hydrates as a result, greatly improve strength, adhesion, resilience, impermeability, chemical resistance and durability properties of mortars and concrete [8–12]. These materials are suitable for making different structural and non-structural pre-cast products such as tile adhesives, frontage coatings, coverings, decorative finishes and as repair materials in road buildings.

The incorporation of synthetic polymers in Portland cement mortars and concrete has been started in the 1950s [13]. Since then, a greater interest on the use of synthetic polymer latex over the use of the natural rubber latexes have been widely used and applied in construction industries [14,15]. Polymer latexes are water-insoluble polymer particles suspended in an aqueous solution. They are composed of a core made of the water-insoluble polymer and a stabilization system used to avoid flocculation of the colloidal system. Presently, latexes of a single or combinations of polymers like polyvinyl acetate, copolymers of vinyl acetate–ethylene, styrene–butadiene, styrene–acrylic, and acrylic and styrene butadiene rubber emulsions are generally used to produce cement composite [16–21].

Practical applications for radiation processing of materials have been involving since the introduction of this technology nearly 50 years ago. The gamma radiation causes both cross-linking and degradation during treatment, but one of these effects may be predominated in some materials. Cross-linking is the most important effect of polymer irradiation because it is usually accompanied with an increase of the number of the polymeric chains under the effect of irradiation dose, leading to the formation of a network structure. Several studies indicated that, during irradiation polymerization an interaction between calcium silicate hydrate formed during the hydration reaction of the blended cement and the polymer presents in the pores takes place [22–24]. So an enhanced interphase bonding and as a result, an improvement of the mechanical strength, thermal and chemical environmental properties of performed parts, workability, abrasion, bond strength, adhesion with substrates, or waterproofing properties of mortars and concrete takes place [25,26]. The objective of the present work aims to study the effect of partial replacement of standard sand by white sand, styrene–acrylic ester and different doses of γ-irradiation on physic-mechanical properties of the composite.

2. Experimental

2.1. Materials

A freshly produced sample of ordinary Portland cement (OPC) type (I) was obtained from the National Cement Company of Egypt. White sand (WS) has high proportions of silica content with 99.5% consist mainly of quartz, grain size ranged from 0.25 mm to 0.15 mm, heavy metal less than 0.1%, specific surface area was 195 $m^2 g^{-1}$ measured by surface area instrument Nova 2000, as well as good adsorption performance, wetting properties, increase fire resistance and increase thermal conductivity. It was obtained from the best mountains in Sinai (land of sand). Also, the standard sand (SS) was used in this study has a SiO_2 content over 99%, Blaine surface area of 395 m^2/kg and a grain size ranged from 0.42 mm to 0.15 mm; the chemical oxide composition are presented in Table 1. The styrene acrylic ester (SAE) latex was supplied from Clariant Egypt. It has a density of 1.04 g/cm^3, solid content percent 57 $\pm$ 1, milky white liquid.

2.2. Sample preparation

In this study, white sand cement mortar specimens were prepared by a partial replacement of standard sand (SS) by different ratios of white sand (WS) to obtain three types of cement mortars. The resulting mortars were designated as 1OPC:2SS:1WS, 1OPC:1SS:2WS and 1OPC:0SS:3WS. The standard (optimum) water of consistency was employed [27]. The resulting cement

Table 1
Characteristics of chemical oxide composition (%) of the materials used.

	Chemical oxide composition (%)		
	Ordinary Portland cement (OPC)	White sand (WS)	Standard sand (SS)
CaO	64.50	0.04	0.01
SiO_2	21.56	99.30	99.7
MgO	3.34	0.005	0.01
Na_2O	0.20	0.009	0.01
K_2O	0.70	0.0002	0.01
Al_2O_3	5.40	0.08	0.07
SO_3	1.48	0.004	–
Loss of ignition	1.25	0.32	0.03