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Polypropylene fiber reinforced cement mortars containing rice husk ash and nano-alumina

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HIGHLIGHTS

- Effects of RHA and nano-alumina in PPF reinforced cement mortars were investigated.
- Water absorption, drying shrinkage, compressive and flexural strength were assessed.
- Addition of PPF resulted in significant increase in flexural strength of the mortars.
- Positive interactions between PPF and RHA resulted in the lowest drying shrinkage.
- The interfacial transition zone and microstructure were studied by using SEM and XRD.

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ABSTRACT

This paper presents the effects of incorporating two supplementary cementitious materials: rice husk ash (RHA) and nano-alumina (NA) in polypropylene fiber (PPF) reinforced cement mortars. RHA is an agricultural waste material and thus recycling of this material has substantial economic and environmental benefits. Compressive strength, flexural strength, water absorption and drying shrinkage of the hardened composites were investigated. The interfacial transition zone and the microstructures were studied by using scanning electron micrograph (SEM) and X-ray diffraction (XRD) analysis. A slight increase in compressive strength of mortar was observed by using up to 10 wt% of RHA as a replacement of cement. However, addition of nano-alumina helped the compressive strength of mortar remain approximately equal to that of the control specimen even when 20 or 30 wt% RHA was used. Addition of polypropylene fibers resulted in significant increase in the flexural strength of the mortar specimens. It was also observed that NA and PPF could reduce water absorption by pore blocking effect. The positive interactions between polypropylene fibers and RHA resulted in the lowest drying shrinkage of the fibrous mortar containing RHA. XRD analysis showed that the intensity of Alite and Belite phases decreased and new peak of portlandite produced with the addition of NA. The addition of RHA enhanced the late strength of the cement composites. Consequently, the combined addition of RHA, NA and PPF has resulted in increasing of flexural strength and reduction in both water absorption and drying shrinkage of mortars.

1. Introduction

Concrete can be made greener by using waste materials that reduce its environmental impact such as the reduction of CO_2 emission in cement production. According to the European Cement Association, the concrete technology today allows for new buildings to be built with 60% less energy use and CO_2 emissions over the lifecycle of the building than conventional buildings constructed 20 years ago [1]. In the mix design, there are also extra steps taken to improve the sustainability of a structure with a long life cycle. Fly ash, blast furnace slag, recycled concrete, power plant waste, rice husk ash, waste glass, red mud, burnt clay, etc. are some of the waste materials used in concrete. Rice husk ash (RHA) is a carbon neutral green product and several ways are currently being

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used for disposing them [2–4]. Annually a large amount of rice is produced in the rural areas of different countries such as Iran, Malaysia, Thailand, Bangladesh, India, Pakistan, Myanmar etc. Huge quantities of rice husk are produced during the processing of this rice. The rice husk is used as fuel which generates the rice husk ash. Incorporating rice husk ash in concrete as a cement replacement has many environmental and economic advantages. RHA is a good pozzolan that can be used to make concrete. Using rice husk ash in concrete has been examined by many researchers around the world. The initial and important reviews on the use of RHA in concrete focused on the mechanical performance of concrete [2–9]. However, recent studies have mostly worked on the

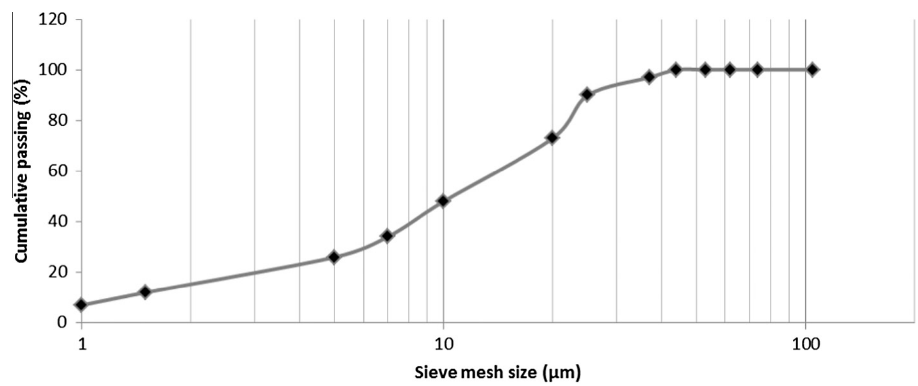

Fig. 1. Particle size distribution of RHA.

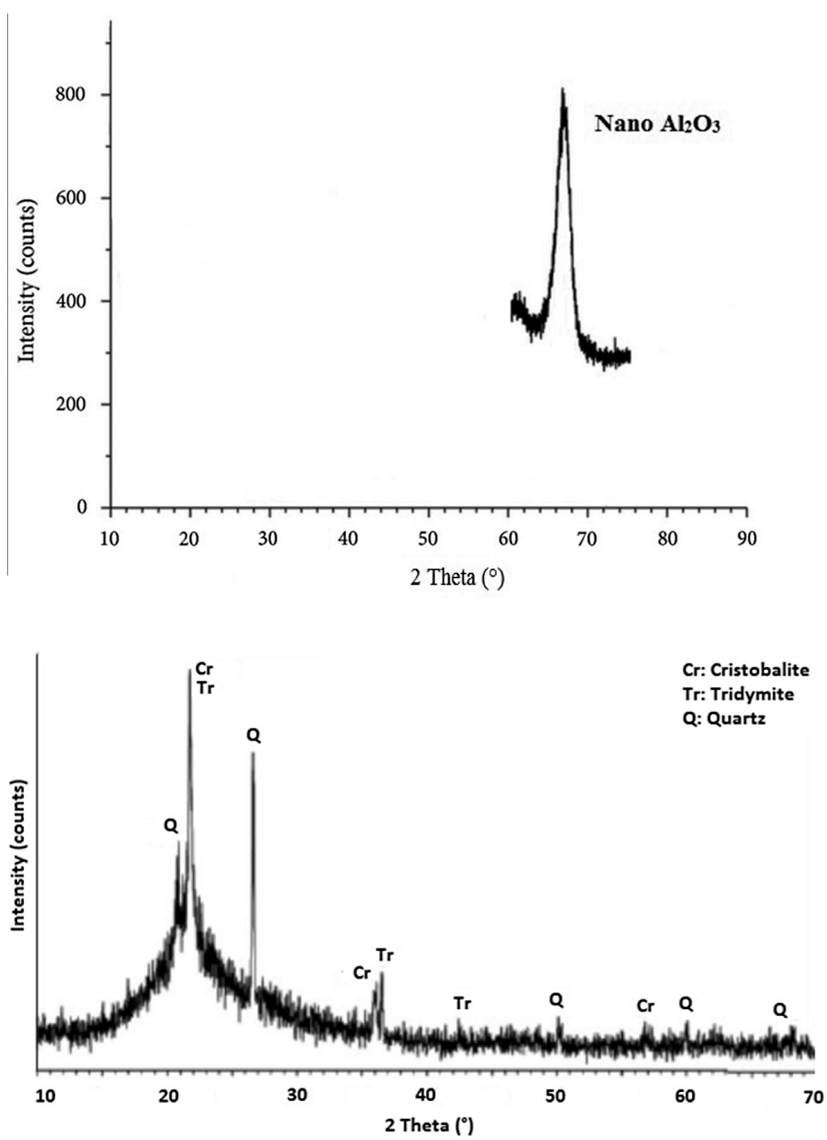

Fig. 2. XRD diagram of nano-Al_2O_3 (top) and RHA (bottom).