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Strength, Elastic Properties and Fiber–Matrix Interaction Mechanism in Geopolymer Composites

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Abstract: The current geopolymers have limited mechanical strength against the effect of tension, which makes them susceptible to brittle failure. However, owing to their potential as a sustainable construction material, there is growing interest in improving the poor mechanical properties of geopolymers. This study experimentally investigated crucial properties of polypropylene-fiber-reinforced fly ash-based geopolymer composites. The effects of polypropylene fibers (PPF) addition (0.5%, 1.0% and 1.5% by volume) on the mechanical properties of the geopolymer composites were investigated with respect to compressive and flexural strength, deformation behavior of Young's and shear moduli, and resilience capacity. In addition, scanning electron microscopy was performed to establish the morphology of the geopolymeric matrix and the fiber–matrix interfacial interaction. The addition of PPF significantly increased the flexural strength: compared with the control, at 7 days it was 27% greater for the 0.5% PPF composite and 65% greater for the 1.0% PPF composite. By 14 days it was 31% and 61% greater, respectively. By contrast, the 1.5% PPF composite had lower strength parameters compared with the control because the fiber dispersion increased the porosity. Similar trends were seen for resilience. The SEM observations showed the dispersion of the fibers and helped elucidate the fiber–matrix interaction mechanism.

Keywords: geopolymer; fibers; resilience; elastic modulus; stress–strain; SEM

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1. Introduction

The need for environmentally friendly construction materials for sustainable development is a pressing environmental issue in the construction industry. The concrete industry is said to be a substantial contributor to global warming owing to the use of Portland cement as the main component in the production of concrete and other cement-based construction materials. The cement industry is responsible for approximately 5–7% of the CO_2 emissions worldwide [1–3]. However, the use of concrete and cement-based composites, as the most widely used construction materials, remains unavoidable for the foreseeable future. In this respect, efforts to find alternatives to Portland cement are necessary. In recent years, there have been considerable developments in a new type of inorganic cementitious material called "geopolymer". Geopolymers are amorphous three-dimensional alumina-silicate binder materials first named and developed by Davidovits in the late 1970s [4]. These materials have been limited to small-scale niche applications due to their low flexural and compressive strength, and they are prone to sudden brittle failure [5–7]. However, adding fibers can improve the strength of the resulting product. Studies using different types and amounts of fibers to examine their effect on the behavior of the binder have been conducted using common mechanical tests [8–15].