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Abstract

Banana Fiber-Reinforced Geopolymer-Based Textile-Reinforced Mortar †

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Abstract: Textile-reinforced mortar (TRM) is an effective method for confining concrete elements to elevate the axial load resistance and upgrade the overall performance of concrete. TRM is a promising alternative to carbon-fiber-reinforced polymers (CFRP) which are commonly used to strengthen concrete and are known to be expensive since they require a huge amount of energy in processing these materials. Green technologies can be applied in this process, following the same TRM principles of confinement, replacing conventional cement or epoxy-based mortars and synthetic textiles towards sustainable concrete strengthening technology. This is through the utilization of a geopolymer mortar reinforced with short banana fibers (BF) and long BFs as textiles. Geopolymer mortar presented in this paper is composed of fly ash and silica fume as the binder, sand as the filler, sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) as the activator and BFs as the reinforcement and textile. Geopolymerization generates significantly less carbon dioxide (CO_2) while BFs are known for having attractive mechanical properties, are cost effective and abundant in nature, and thus the use of this fiber will significantly minimize the huge waste produced from banana plantations after a one-time fruit harvest. The geotextile or geogrid used to wrap the concrete cylinder samples is made up of 2 mm-long BF yarns with weights ranging from 150 to 450 grams per square meter that varies with grid sizes from 10 mm, 15 mm to 25 mm for both orthogonal directions considering the lightweight characteristic of BFs. Twelve TRM designs were used to strengthen the concrete cylinders with three samples each. TRM design parameters vary in the thicknesses of the geopolymer mortar covering and the size of the geotextile grids. Eighteen of the geotextiles used were coated with a polymer to protect the fibers while the other eighteen geotextiles remained uncoated. A total of thirty-nine concrete cylinders with 150 mm base diameter and 300 mm height cured within 28 days were prepared, for which 36 cylinders were confined with green TRM with different parameters while three of the plain concrete cylinders served as the control specimens. This is to maximize the investigation on the potential of green TRM in confining concrete and to determine the variations in compressive strengths and mode of failures of confined and unconfined concrete specimens. Results highlighted notable enhancement in the mechanical properties of the modified plain concrete after 28 days of TRM curing using a universal testing machine (UTM). Likewise, a confinement theory of the optimum TRM design was modeled mathematically to evaluate the effects of concrete confinement and overall load carrying capacity enhancement gained from additional strength transferred by the TRM to the concrete element.

Keywords: green TRM; concrete confinement; natural fiber; modified concrete; compressive strength

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