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Microstructural Characterization of Basalt Fiber-Reinforced Green Nanocomposites

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Abstract – The aim of this study was to enhance the microstructural activity of micro basalt-fiber-reinforced polymer (GP) mortars incorporating fly ash by adding Nano-Titania. Four distinct dosages of titania were utilized to make GP mortars with 2% basalt fiber. The microstructural effects of the GP mixes were evaluated using Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD). The SEM analysis revealed that nano-Titania significantly improves the microstructure of GP. The XRD results showed a rise in hump width between 25° and 35°, indicating the formation of calcium-silicate-hydrate (C-S-H). The incorporation of Nano-Titania into the GP matrix led to a denser microstructure, contributing to improved mechanical properties. The study concludes that adding Nano-Titania to basalt fiber-reinforced GP mortars enhances their microstructural characteristics, leading to potential applications in advanced construction materials.

Keywords – geopolymer; nanoparticles; Scanning electron microscopic (SEM), X-ray diffraction (XRD)

I. INTRODUCTION

Cement manufacture has been an international problem with pollution in the last few decades due to the large amount of carbon dioxide it releases. The outstanding binding properties of geopolymers (GP) make them a highly recommended alternative to Portland cement in concrete development [1]. To create these mortars, activated silicate of a product might use an alkaline solution to synthesis materials like fly ash [2-4]. Unlike regular concrete, GP has been steadily improving structural performance over time [5-7]. Research has shown that GP mortars modified with fibers have superior mechanical performance compared to GP mortars that do not include fibers. One possible explanation for the improved mechanical behavior is the usage of micro-basalt fibers (BF) effectively, which reduces micro-cracking and limits energy absorption when the pull-out process [8]. Incorporating micro-BF into GP mortars made from fly ash increases their compressive strength (CS), decreases their dry shrinkage, and shortens the setting time [9]. For example, adding 10 wt. % micro-fibers to GP mortar increased its CS by 37%, according to research that looked at the impact of micro-fibers on the GP mortar [10]. Nevertheless, the related CS increased somewhat with adding the micro-fibers at a 15-30 wt. % concentration. Thus, it is important to consider the proper usage of additional micro-fibers while making the GP mortars to effectively strengthen the intended CS. One study found that adding 2 weight percent basalt fiber to the binder improved the CS of GP plaster by 40% [11].

Incorporating both nano-Titania and basalt fibers into GP mortars is hypothesized to synergistically enhance their mechanical properties and microstructural characteristics. Nano-Titania is known for its potential to improve the densification and durability of composite materials, while basalt fibers contribute to mechanical strength and toughness. The combined use of these materials aims to create a geopolymer matrix that leverages the benefits of both components, potentially leading to superior performance in construction applications. Examining the effects of different nano-Titania percentages on the microstructural characteristics if basalt-fiber-reinforced (FR) GP bricks has been the primary objective of this work. We observed the related influence on several mechanical characteristics of GP by synthesizing GP mortars with Titania ranging from 0% to 4% wt. and 2% BF, with each increase of 1%. We used scanning electron microscopy, or SEM and X-Ray Diffraction (XRD) to analyze the microstructure and mineralogy of the cracked specimens.

The primary objective of this study was to examine the effects of different percentages of nano-Titania on the microstructural characteristics of basalt-fiber-reinforced geopolymer mortars. Specifically, this research aimed to observe the related influence on several mechanical characteristics by synthesizing GP mortars with titania ranging from 0% to 4% wt. and incorporating 2% basalt fiber in each mixture. This work enhances microstructure, mechanical properties, and sustainability of basalt-fiber-reinforced geopolymer mortars using Nano-Titania. Improved durability, understanding of C-S-H formation, and advanced construction applications make it significant for developing stronger, more resilient, and eco-friendly building materials.

II. Materials and Method

A. *Materials*

The current study employed Nano-Titania with the grain size distribution of 1-30 nm. Primarily, Titania is comprised of 99.68% Titania. Added BF for the current research comprised 2 mm and 7 µm of nominal length and diameter correspondingly, while elastic modulus and tensile strength of BF were 70 GPa and 1800 MPa, respectively. Class F-FA was used in the current study to fulfill its function as an aluminosilicate precursor. For all GP mortars under investigation, the alkaline solution to FA with a 0.45 ratio was adopted, while a 2.50 ratio was chosen for sodium silicate to NaOH [12]. Prior to fabricating the GP mortars, NaOH pallets were kept in water for dissolution and further stirring in sodium silicate solution. The process was carried out 24 hours earlier than GP mortars fabrication which helped secure a 12 M alkaline solution. Quantities of ingredients included NaOH = 0.23 kg, sodium silicate = 0.58 kg, fly ash = 1.8 kg, BF = 2%, and titania was varied between 0-4%.

B. *Fabrication of Specimens*

To make new GP mortars, we used a Hobart mixer to dry mortar BF and FA for 5 minutes at a slower pace than usual It was somewhat quicker to mortar an alkaline solution containing varying percentages of Titania after two materials had been dry mortared. We kept on with the mortaring process until the GP concrete was completely uniform. The next step was to fill the molds with fresh mortar and set them aside to cure at 80°C. Following a day of temperature curing, the specimens that are used were demolded and left to cure at ambient temperature. Curing the demolded samples at room temperature for the next 28 days improved their performance. After subjecting the samples to compression testing, which allowed us to determine the matrix's internal structure, we covered the broken samples with old foils to prevent the formation of charge prior SEM examination.

III. RESULTS AND DISCUSSION

A. *Scanning Electron Microscopic Analysis*

By analyzing the fractured surface, SEM examination may reveal the GP matrix's fracture performance. Figure 1 displays the results of the SEM study for all the GP mixtures. Distinct variations are seen in the shattered surface of the nano-Titania-containing samples and the reference samples that do not include nano-Titania. Most of the FA with voids that have either not responded or have just partially reacted are either the regular GP mix or the mix with fewer nano-Titania. When comparing GPs with 2% and 3% nano-Titania content, a densified microstructure becomes apparent. The C-S-H gel or C-A-S-H gel's architecture, which incorporates both FA microparticles and Titania nanoparticles, is responsible for this.

B. *XRD Analysis*

Figure 2 shows the XRD findings of the control and different concentrations of titanium nanoparticles in the produced GP. Raw FA diffractograms showing a broad hump between 25° and 35° indicate the formation of a glassy GP binder, which is solely responsible for increasing the mechanical properties [13]. Crystals of quartz, muscovite, the mineral magnetite, and hematite were among the mineral phases found. present in FA powder still exists on FA-sourced GP with/without modification by nano-Titania (additives).

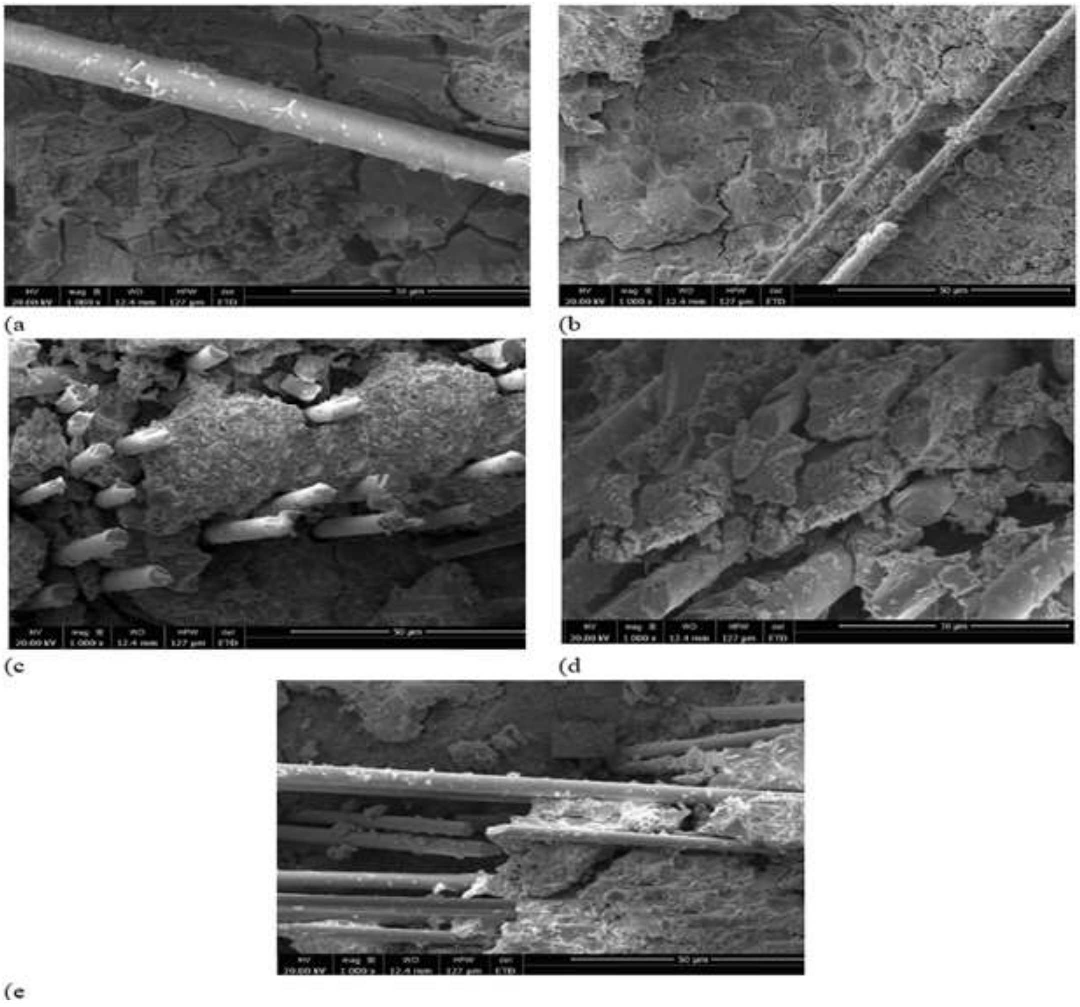

Figure 1. SEM images of GP mixes (a) BGP-0%NTO (b) BGP-1%NTO (c) BGP-2%NTO (d) BGP-3%NTO (e) BGP-4%NTO

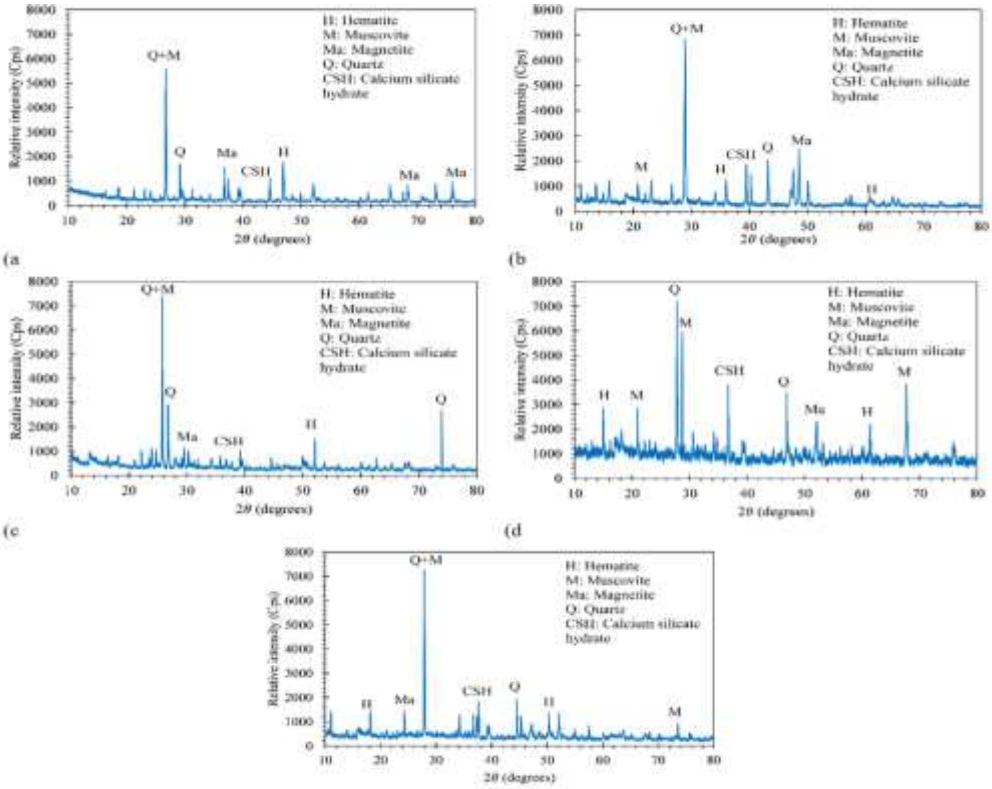

Figure 2. XRD diffraction patterns of GP mixes (a) BGP-0%NTO (b) BGP-1%NTO (c) BGP-2%NTO (d) BGP-3%NTO (e) BGP-4%NTO

The humps might be explained by the probability of nanoparticles of nano-Titania being dissolved, which in turn extend the GP network by developing C-S-H about primary binder such as N-A-S-H [7-8]. This pattern is in line with the published results where variety of studies utilized varying proportions of calcium compounds with new aluminosilicates (slag, FA, metakaolin etc.) to fabricate the GP mortar.

IV. CONCLUSION

By filling the small nano-voids between the fly ash microparticles, the addition of nano-Titania to the GP construct makes it denser, as seen on scanning electron micrographs. The functional linking seen in the scanning electron micrographs of the BF or GP structure is explained by nano-Titania's ability to refine and construct a densified mesh of GP mix. Perhaps the observed increase in the hump between 25° and 35° in the XRD analysis is due to the formation of calcium ceramics hydrate (CSH) approximately a primary binder, such as sodium aluminosilicate (NASH), as a result of the closing of nano-Titania small particles.

REFERENCES

[1] [1] Mehta, A. and R. Siddique, Properties of low-calcium fly ash based geopolymer concrete incorporating OPC as partial replacement of fly ash. Construction and Building Materials, 2017. 150: p. 792-807.

[2] [2] Chiranjeevi, K., M. Vijayalakshmi, and T. Praveenkumar, Investigation of fly ash and rice husk ash-based geopolymer concrete using nano particles. Applied Nanoscience, 2023. 13(1): p. 839-846.

[3] [3] Gopalakrishna, B. and P. Dinakar, Mix design development of fly ash-GGBS based recycled aggregate geopolymer concrete. Journal of Building Engineering, 2023. 63: p. 105551.

[4] [4] John, S.K., et al., Effect of addition of nanoclay and SBR latex on fly ash-slag geopolymer mortar. Journal of Building Engineering, 2023. 66: p. 105875.

[5] [5] Adesina, A., Performance and sustainability overview of alkali-activated self-compacting concrete. Waste Disposal & Sustainable Energy, 2020: p. 1-11.

[6] [6] Duxson, P., et al., Geopolymer technology: the current state of the art. Journal of materials science, 2007. 42(9): p. 2917-2933.
[7] [7] Zhuang, X.Y., et al., Fly ash-based geopolymer: clean production, properties and applications. Journal of Cleaner Production, 2016. 125: p. 253-267.
[8] [8] Han, B., et al., Reinforcement effect and mechanism of carbon fibers to mechanical and electrically conductive properties of cement-based materials. Construction and Building materials, 2016. 125: p. 479-489.
[9] [9] Punurai, W., et al., Mechanical properties, microstructure and drying shrinkage of hybrid fly ash-basalt fiber geopolymer paste. Construction and Building Materials, 2018. 186: p. 62-70.
[10] [10] Timakul, P., W. Rattanaprasit, and P. Aungkavattana, Improving compressive strength of fly ash-based geopolymer composites by basalt fibers addition. Ceramics International, 2016. 42(5): p. 6288-6295.
[11] [11] Payakaniti, P., et al., Electrical conductivity and compressive strength of carbon fiber reinforced fly ash geopolymeric composites. Construction and Building Materials, 2017. 135: p. 164-176.
[12] [12] Alomayri, T., Performance evaluation of basalt fiber-reinforced geopolymer composites with various contents of nano CaCO3. Ceramics International, 2021.
[13] [13] Bayiha, B.N., et al., Effect of limestone dosages on some properties of geopolymer from thermally activated halloysite. Construction and Building Materials, 2019. 217: p. 28-35.