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Sustainable Cement Mortars: Evaluating Volcanic Ash and Nano-Silica as Partial OPC Replacements

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ABSTRACT

This study evaluates the mechanical performance of cement mortar mixes incorporating volcanic ash (VA) and Nano-silica (NS) as partial replacement for Ordinary Portland Cement (OPC). Three mixes were examined: a control mix (45C), a mix with 30% VA (45CVA30), and a mix with 2% NS (45CNS2). Compressive, flexural, and tensile strength were assessed at multiple curing ages. Results revealed that the inclusion of NS led to notable improvements in all measured mechanical properties. The 45CNS2 mix exhibited the highest compressive strength at early ages and maintained superior performance up to 90 days. Flexural strength followed a similar trend, with NS contributing to increased matrix stiffness. Tensile strength results showed significant enhancement in the NS mix compared to both control and VA samples. In contrast, the VA mix showed lower strength values across all tests and ages. The findings confirm that NS, even at low replacement levels, is highly effective in enhancing the mechanical behavior of cementitious composites, making it a promising additive for durable and high- performance construction materials.

Keywords: compressive strength; flexural strength; mechanical properties; ordinary Portland cement; tensile strength