VALORIZATION OF GRANITE QUARRY DUST AS MINERAL FILLER IN PORTLAND CEMENT: MECHANICAL PERFORMANCE AND DURABILITY ASSESSMENT

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Abstract:

Granite dust, a fine-grained by-product of quarry processing operations, is generated in large volumes with limited reuse pathways, contributing to land degradation and disposal pressures in resource-extraction regions. This study evaluates its potential as a partial fine aggregate replacement in Portland cement mortar, targeting both performance optimization and industrial waste reduction. Granite dust sourced from a commercial quarry processing plant was characterized by X-ray fluorescence (XRF) and X-ray diffraction (XRD), revealing a silica-dominated composition (SiO_2 = 71.22%, Al_2O_3 = 19.84%, Fe_2O_3 = 2.75%) with quartz, feldspar, and mica as the principal phases. Mortar mixes were designed at a water-cement ratio of 0.5, with granite dust replacing fine aggregates at 0%, 5%, 10%, 15%, 20% and 25% by weight. Fresh properties, compressive strength at 3, 7 and 28 days, alkali-silica reactivity (ASTM C1260), sodium sulphate soundness (ASTM C88), and resistance to sulphuric acid and sodium chloride exposure were assessed. Compressive strength peaked at 10% replacement (41.6 MPa vs. 38.9 MPa for the control; approximately 7% increase), attributable to enhanced particle packing density. Beyond 10%, strength declined progressively, though mixes up to 15% replacement retained superior durability under aggressive chemical exposure relative to the control. ASR expansion values remained below the ASTM C1260 threshold of 0.10% across all mixes, and soundness losses satisfied ASTM C88 limits. These results establish 10–15% granite dust replacement as a technically viable and sustainable substitution range, offering a scalable strategy for quarry waste valorization without compromising structural concrete performance.

Keywords: Granite dust, waste valorization, Portland cement, compressive strength, mortar, alkali-silica reactivity.