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Full Length Article

Comprehensive evaluation of sustainable Self-Compacting concrete (SCC) with High-Density Polyvinyl Chloride (HDPVC) recycled pipes as partial coarse aggregate replacement

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ABSTRACT

This study explored the potential of recycled High-Density Polyvinyl Chloride (HDPVC) from scrap pipes as an environmentally friendly substitute for natural coarse aggregate in self-compacting concrete (SCC). incorporating fly ash as a supplementary cementitious material. The influence of varying HDPVC replacement levels (5 %, 10 %, 15 %, 20 %, and 25 %) by volume of natural coarse aggregate on the fresh, hardened, and durability characteristics of SCC was examined. The experimental results indicated satisfactory in passing ability, flowability, and segregation resistance for mixtures containing up to 25 % HDPVC. Optimal strength enhancement was observed at 10 % HDPVC replacement, resulting in a 20 %, 16 %, and 17 % improvement in compressive, splitting tensile, and flexural strength, respectively, at 28 days of curing relative to the reference mixture. Conversely, a subsequent decline in strength at higher levels occurred until it nearly equaled that of the control mixture. Furthermore, strong correlations of 0.9704 and 0.9117 were noted in comparison with the compressive strength with Schmidt rebound number and ultrasonic pulse velocity (UPV), respectively. SCC with HDPVC particles demonstrated superior resistance to sulfuric acid attack while maintaining adequate resistance to salt attack compared to reference mixture. However, significant weight and compressive strength losses were recorded at elevated temperature (450 °C), limiting the material's application in such conditions. Based on the comprehensive evaluation of fresh, hardened, and durability properties, the SCC mixture with 10 % HDPVC replacement is advisable for general construction applications where enhanced mechanical performance and improved acid resistance are beneficial, excluding high-temperature environments due to observed material degradation.

1. Introduction

Self-compacting concrete (SCC) constitutes a major branch within the broader classification of High-Performance Concrete (HPC), which is generally used with cast-in-place large structures in ginormous projects with highly dense reinforcement [1,2]. The SCC has offered some significant advantages over conventional concrete, primarily due to its faster placement and improved reliability during construction [3,4]. In general, the widespread use of reinforced concrete (RC) in bridges, buildings, highways, dams, and other constructions has resulted in a significant demand for concrete ingredients like water, cement, fly ash (in SCC), and aggregate [5]. Furthermore, aggregate consumption in concrete production is significantly higher than that of cement and water, almost 7 times higher than the other concrete ingredients [6,7]. This high demand for aggregate poses a significant threat to natural resources [8]. This high material consumption raises concerns about environmental sustainability in addition to CO_2 emissions [9–11]. Therefore, the incorporation of recycled industrial waste has the potential to revolutionize civil engineering by promoting sustainable construction practices [12–14]. This approach reduces reliance on natural resources and contributes to the development of building materials that offer improved efficiency [15–17]. Recent studies have explored using recycled solid waste to replace aggregate such as plastic [18], glass [19], electronic waste [20], ceramic waste [21], and rubber [22].

Globally, Polyvinyl Chloride (PVC) utilization places it among the most commonly employed plastics. PVC exhibits superior stiffness

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