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Mechanical and microstructural characterization of fly ash blended self-compacting concrete containing granite waste

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ABSTRACT

This study examines the mechanical characteristics (compressive strength, split tensile and flexural strength) and microstructure characteristics (scanning electron microscopic (SEM), energy dispersive X-ray spectrometry (EDS), X-ray diffraction (XRD) and Fourier transform infrared radiation (FTIR)) of fly ash blended self-compacting concrete (SCC) comprising of granite waste (GW). Mechanical performance of fly ash blended SCC augmented on the incorporation of up to 40% GW as a substitution of fine aggregate. SEM analysis revealed that the incorporation of GW densified the binder-aggregate matrix of resulting SCC. However, EDS, XRD and FTIR analysis revealed that there was a negligible effect of GW on the development of hydration products. It was thus concluded that the enhancement in the mechanical performance of the resulting SCC (prepared with GW) was mainly due to the filler efficacy of GW.

1. Introduction

Self-compacting concrete (SCC) is the upgraded version of normally vibrated concrete (NVC) that can smoothly move in narrower and jam-packed reinforced sections. It has many advantages over NVC, for example, increases construction speed, improves quality of concrete without voids and honeycombing, and reduces labour cost and noise pollution [1–5]. Due to several advantages of SCC, the utilization of SCC has become escalated with the advancement in construction technology. However, the cost of SCC is very high as compared to the NVC since it comprises excessive cement content and chemical admixture for attaining adequate stability and flowability. Several investigations have been done by earlier researchers who had effectively employed diverse secondary cementitious materials such as fly ash, ground granulated blast furnace slag, metakaolin, and silica fume in SCC to reduce the cement amount [6–13]. These cementing materials generally augment the engineering characteristics of concrete by the action of pore refinement provided by their small size particles as well as pozzolanic activity [11,14,15]. Furthermore, to improve the cost-effectiveness and sustainability of SCC, the waste materials or recycled sand, especially having higher fines can be utilized as a substitute for river sand aggregate. These types of materials can also contribute to the filler content of SCC and additionally may improve fresh and hardened characteristics of SCC.

Granite waste (GW) is one such type of waste material produced during the extraction and transformation of granite stones, which comprises a high quantity of fines. Accumulation of this waste is endlessly increasing, which is polluting the environment as well as affecting the human too. Earlier, studies have been performed on the use of GW in the development of mortar and NVC. However, few studies are available on its application in SCC. Cheah et al., [16] produced ternary blended mortar by full volumetric replacement of fine aggregate with GW and obtained the highest compressive strength at 60% replacement level of GW. Vyas and Gupta [17] found better mechanical and durability performance of granite blended mortar as compared to the conventional cement mortar. Vijayalakshmi et al., [18] and Ghannam et al., [19] found the highest compressive strength at a very low substitution level (i.e. 10%) of natural fine aggregate with GW in NVC. Improvement in compressive and flexural strength of NVC was also observed by Singh et al., [20,21] on the substitution of fine aggregate with GW. Ghorbani et al., [22] found about 11% and 8% improvement in compressive and split tensile strength characteristics, respectively, at 10% substitution level of cement with GW.

Elyamany et al., [23] and Sadek et al., [24] stated the improvement

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