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Robustness of self-compacting concrete incorporating bone china ceramic waste powder along with granite cutting waste for sustainable development

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Abstract

Keeping sustainability at the centre of this work, two solid waste materials have been selected for this study. First is bone china ceramic waste powder (BCCWP) obtained from broken or distorted bone china ceramic waste products, and the second is granite cutting waste (GCW) from the granite cutting and shaping industry. The present study aims at assessing fresh state, mechanical and durability characteristics of the SCC mixes incorporating BCCWP and GCW as cement and fine aggregate replacement, respectively. In a preliminary state, the raw BCCWP was evaluated for various pozzolanic activity tests such as the Frattini test, strength activity index and lime saturation test. SCC mixes were tested for compressive strength, splitting tensile strength, corrosion and chloride resistance tests. SCC mixtures were also tested at elevated temperatures by conducting thermogravimetric analysis (TGA) and differential thermal analysis (DTA) tests. Outcomes of fresh properties were found in the satisfactory limit as per EFNARC standard, except the SCC mix prepared with 30% BCCWP and 40% GCW. SCC mix with 10% BCCWP and 30% GCW showed the maximum strength properties. Moreover, statistical analysis using ANOVA was carried out to find the effectiveness of BCCWP and GCW parameters on various hardened state characteristics. From ecological and economic analysis, lesser embodied energy and embodied carbon dioxide emission, as well as cost reduction, was observed for SCC mixes containing BCCWP and GCW.

Introduction

Infrastructure expansion and modernization are quintessential to the economic growth of every developing country. Population explosion coupled with economic factors have further intensified the demand and led to the unprecedented rise in industrial production globally. Traditionally this demand was fulfilled by exploiting and depleting natural resources. Huge industrial waste is also produced as a by-product during the process. This has caused adverse environmental effects with severe ramifications like pollution, global warming, soil degradation, etc. As a result, the research community is presented with the challenge to look for sustainable infrastructure and building materials. Recycling and reuse of waste material have shown tremendous potential in reducing dependency on natural resources while tackling pollution up to a certain extent. A study suggests that global annual consumption of concrete stands at five billion tonnes while domestic demand is 160 million tonnes (Singh et al., 2016a). Thus it is of utmost importance to supplement concrete with environmentally friendly and sustainable building materials. The study of alternative construction materials has been the most sought area among researchers in the past two decades.