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Performance of self-compacting concrete incorporating waste glass as coarse aggregate

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The purpose of this paper is to develop gather data on the rheological and mechanical properties of self-compacting concrete (SCC) containing varying percentages of waste glass aggregate (WGA). In this current experiment, the coarse aggregate was substituted by adding WGA, with replacement percentages of 0%, 10%, 20%, and 30% by weight being investigated. The rheological properties of SCC were performed to explore the consequence of WGA using various methods, including the J-ring, slump flow, L-box, and V-funnel. In contrast, the compressive, flexural, modulus of elasticity, and stress-strain responses of hardened concrete were assessed in this study. The results of the fresh concrete tests revealed that the substitution of an optimal level of waste glass in SCC provides adequate implementation in flowability, passing ability, and viscosity behaviors. Besides, hardened characteristics were shown to have a steady decrease in strength with increasing WGA content in the concrete mixtures.

Keywords: Self-compacting concrete; rheological properties; hardened properties; coarse aggregate; waste glass aggregate

1. Introduction

Concrete is a revolutionary construction material employed in various civil engineering applications. Concrete has evolved significantly over the last century, introducing new concretes and, more recently, self-compacting concrete. Over the last few decades, significant effort has been expended to develop self-compacting concrete (SCC) due to its numerous benefits over conventional concrete, including time potency, reduced on-site labor, improved performance, lower noise levels, and a safer construction working environment [1]. SCC is highly flowable, deformable, and capable of filling formwork without mechanical vibration and encapsulates even in the presence of clogged reinforcement. Additionally, the concrete is produced homogeneous mixes of the composition and exhibits similar engineering and durability properties compared to the conventional vibrated concrete. SCC has a similar composition to conventional concrete, consisting of binder particles, water, aggregates, and admixtures [2]. To regulate the SCC properties distinctly from conventional concrete, it should have higher fine content, and a w/c ratio ranges between 0.33 and 0.36 [3]. Concrete manufacture necessitates a considerable amount of natural resources, primarily occupied by coarse aggregate in the concrete mix. To achieve sustainability and lower the carbon footprint, concrete manufacturers must reduce traditional resources and consume waste materials. A massive amount of solid waste is disposed of annually at landfills, of which waste glass is a significant portion. According to the U.S. Environmental Protection Agency, America produced around 10.37 million tons of waste glass in 2013, of which only 28% was recycled [4]. In Bangladesh, about 7,690 tons of municipal waste are generated every day, with waste glass accounting for approximately 0.8% of total waste collection each year [5, 6]. According to Alamgir and Ahsan [7], the amount of waste glass created from any glass goods such as utensils, bottles, electric bulbs, and ceramics is around 14,770 tons per year, with a market worth of USD 249,550.

Although glass is technically recyclable, the expensive cost of cleanliness and shielding attire prevents most businesses from reusing it [8]. Landfills are the final destination for this unneeded waste glass, yet glass does not degrade in landfills. This waste glass can be used as a raw material in concrete manufacturing, reducing the need to extract natural resources for the construction industry [9]. Glass aggregates are usually hard but brittle in nature, contain poorly graded and sharp forms, and have flat surfaces that are less susceptible to abrasion [8]. The main sources of waste glasses are waste containers, window panels, bulbs, liquor bottles and electronic equipment's'. According to chemical composition glass is a mixture of silica, soda and lime. Among different types of soda-lime or ordinary waste glass widely used in concrete production because of their pozzolanic-cementitious behavior [10]. Ordinary waste glass used to produce containers, bottles, windows etc. Secondly lead glasses, from color TV funnel, cathode ray tube (CRT), electronic parts etc. are also used in concrete production [10]. In the past, several researchers have attempted to use discarded

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