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Effect of water to binder ratio and particle size distribution of waste glass powder on the compressive-strength and modulus of elasticity of normal-strength concrete

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ABSTRACT

This paper aims to experimentally study the impact of waste glass powder (GP) as a partial cement replacement (up to 20%) with two different particle size distributions ((55 μm < GP-A < 135 μm) and (55 μm > GP-B)) on the compressive strength and Modulus of Elasticity (MOE) of concrete. The concrete mixes for GP-A considered in this study have water to binder ratio (w/b) of 0.49 and 0.57, whereas only a w/b ratio of 0.57 was considered for GP-B mixes. The experimental data obtained were used to develop different models to predict the elastic modulus of GP-modified concrete.

The test results showed that the compressive strength and the MOE decreased with the increase of GP content. The size effect of GP as compared to w/b and GP content on compressive and MOE was relatively small. A nearly similar failure behaviour and peak strain were observed for all concrete mixes. The stiffness of the concrete decreases comparatively with an increase in the GP replacement level. Finally, the proposed MOE equations provide better predictions than the empirical models and practice codes considered in this study. They can be used in calculating the elastic modulus of GP-modified concrete.

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KEYWORDS
Cement replacement; glass powder; compressive strength; elastic modulus; stress-strain behaviour; modelling

1. Introduction

Due to a wide range of applications and productions in many forms and types, glass products' uses have grown enormously, leading to large quantities of waste glass. Since glass cannot be biodegraded, dumping it in landfills is not an environmentally friendly solution. The recycling of glass waste has therefore been the focus of the attention of the researchers. Although glass is a unique inert substance that can be recycled repeatedly without altering its chemical properties, it is not possible to recycle all used glass into new glass due to recycling costs, impurities, or mixed colors (Zheng, 2013). There is a strong need for waste glass to be utilized in such a way as to reduce the demand for valuable landfill sites and to provide an environmentally friendly solution.

The phase (amorphous nature) and chemical properties (large quantity of silica and calcium) of the waste glass, when finely ground enough, make it theoretically act as a pozzolanic or even cementitious material (Liu et al., 2013, 2015; Shi et al., 2005). Therefore, the use of waste glass in the powdered form to replace cement in the concrete industry is among the most viable options.

In recent decades, many studies have been carried out on the feasibility of using GP as part of cement substitution. It has been found that the amorphous nature, chemical compositions, percentage

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