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Effect of fly ash and slag on properties of normal and high strength concrete including fracture energy by wedge splitting test: Experimental and numerical investigations

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HIGHLIGHTS

- Concrete properties with and without SCM is examined from as early as 18 h.
- Rate of gain strength will be different for concrete with and without SCM.
- Wedge splitting test was found to be helpful for early age concrete.
- The fracture energy will be lower for concrete with SCM.
- The FE results were in good agreement with experimental results.

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ABSTRACT

The effect of supplementary cementitious material (fly ash and slag) on the properties of concrete was investigated at different ages starting from as early as 18 h in this paper. The tests covered concrete mix with a different amount of supplementary cementitious material (SCM). The effect of SCM on the properties of concrete (compressive strength, splitting tensile strength, modulus of elasticity, Poisson's ratio and fracture energy) was investigated. Properties of concrete including fracture energy of concrete by wedge splitting test (WST) with different percentage of fly ash (FA) and slag were evaluated. For a mix with 50% slag, there was a decline in the values of compressive strength of concrete, splitting tensile strength, modulus of elasticity and fracture energy compared with a mix with 25% FA. The mix with 25% FA also had a higher fracture energy of concrete than the mix with 50% slag. The fracture energy decreased when FA and slag were added at all ages compared to the pure cement mix. A finite element (FE) model was developed and the results from the FE analysis were compared with the experimental work. A good agreement was achieved in terms of fracture energy and splitting load vs crack mouth opening displacement.

1. Introduction

Concrete consists of water, fine aggregate, coarse aggregate, sand and cement. Concrete is a versatile material that can be made into different forms and can withstand harsh environments. Hence it is considered as one of the most important building materials in the construction industry. Given the widespread use of concrete, there is a large motivation to make concrete economical and to reduce carbon footprint from the production of concrete. Carbon dioxide is one of the main greenhouse gases where it contributes to approximately 65% of global warming, with cement manufacturing contributing approximately 5% of global carbon emission [42]. It is estimated that as high as one ton of carbon dioxide gas (CO_2) is emitted from the production of one ton of Portland cement [21] also reported that sourcing raw materials and fuels for manufacturing of cement are becoming a problem due to scarcity. Hence, there is a large incentive to substitute cement in concrete with the reuse of waste material or by-products from industrial processes.

Engineers and researchers are pushing to increase concrete's economic and environmental performance with various supplementary cementitious materials (SCMs). In recent years, SCMs are widely used in concrete construction to replace part of cement.

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