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Influence of mix composition and strength on the fracture properties of self-compacting concrete

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HIGHLIGHTS

- Role of composition parameters of SCC mixes on their fracture behaviour examined.
- Specific fracture energy increases as coarse aggregate volume fraction increases.
- Increase in paste to solids ratio results in large decrease in fracture energy.
- Increase in water to binder ratio reduces specific fracture energy.
- Critical crack opening is dominated by the coarse aggregate volume.

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ABSTRACT

Self-compacting concrete (SCC) has undergone extensive investigations that have led to confidence in its fresh and hardened properties, yet its composition variations raise concerns as to its fracture behaviour. This paper presents the results of an experimental study on fracture behaviour of SCC mixes differing by the coarse aggregate volume, paste to solids ratio (p/s) and water to binder (or cementitious material (w/cm)) ratio. First the size-dependent fracture energy (G_f) has been determined using the RILEM work-of-fracture test on three point bend specimens of a single size, half of which contained a shallow starter notch (notch to depth ratio = 0.1), while the other half contained a deep notch (notch to depth ratio = 0.6). Then the specific size-independent fracture energy (G_F) was calculated using the simplified boundary effect formalism in which the variation in the fracture energy along the unbroken specimen ligament is approximated by a bilinear diagram. Finally, the bilinear approximation of the tension softening diagram corresponding to G_F has been obtained using the non-linear hinge model. It is found that G_F and the critical crack opening (w_c) are dominated by the coarse aggregate volume in the mix and the mix grade. The larger the coarse aggregate volume (or the smaller the paste to solids ratio) the larger are both the mix toughness (G_F) and the critical crack opening (w_c). However, the higher the mix grade the larger is the mix toughness (G_F) but the lower is the critical crack opening (w_c).

1. Introduction

Specific fracture energy and the tension softening diagram of a concrete mix are the most important parameters describing its fracture behaviour. They form a basis for the evaluation of the load carrying capacity of cracked concrete structures [1,2]. According to RILEM recommendations [3], the specific fracture energy (or toughness) can be obtained by the work-of-fracture method requiring tests on notched three-point bend specimens of different sizes and notch to depth ratios.

It is however widely recognised [4–10], that the specific fracture energy of concrete obtained using the RILEM method is dependent on the size of the test specimen and the notch to depth ratio. To eliminate this size dependency, Guinea and co-workers [11–13] and Hu and Wittmann [14] proposed methods to correct the measured size-dependent specific fracture energy (G_f) in order to obtain a size-independent value (G_F). The methodology proposed by Guinea and co-workers [11–13] involves adding the non-measured work-of-fracture due to the curtailment of the tail of the load–central deflection (P–δ) curve recorded in the three-point bend test. On the other hand, the methodology of Hu and Wittmann [14] is based on the observation that the local specific

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