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Alkali resistant glass fiber reinforced concrete: pull-out investigation of interphase behavior under quasi-static and high rate loading

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Abstract

Single fiber model composites of alkali resistant (AR-) glass fibers and a cementitious matrix were used to investigate the pull-out behavior under quasi-static and high speed loading. For fundamental understanding of the effect of the fiber/matrix interphase on the pull-out behavior under impact, differently sized AR-glass fibers were spun. As a first approach, the fiber surface was modified in oppositional ways using the following sizings: one based on a polypropylene (PP, weak) film former and another one based on a styrene-butadiene (strong) film former. Additionally, some of the fibers were kept unsized for comparison. A new 'alternative' approach was employed to determine the local interfacial shear strength, τ_d, and the critical energy release rate, G_{ic}, from the reliable force values of the force–displacement curves. For all fiber surface states, the τ_d and G_{ic} values for high loading rates appeared to be considerably greater than the corresponding parameters for a quasi-static pull-out test. This can be explained using a model based on Zhurkov's kinetic (thermal fluctuation) theory of the strength of solids, which also enabled to estimate the apparent activation energy for interfacial debonding. Both quasi-static and high-rate pull-out tests on this fiber/matrix pair can be considered as 'normal' (slip-dependent interfacial friction was not observed) and their results can be evaluated using the described approaches. The interfacial frictional stress reduced at high-rate pull-out tests for all systems. One of the possible mechanisms responsible for this behavior may be the smoothing of surface asperities upon debonding. As revealed by AFM of fracture surfaces, in the case of unsized fibers or those with the 'strong' styrene–butadiene sizing, the interfacial crack occurs through surface layers of the matrix material adjacent to the fiber, but it may propagate through the weak interface when the fiber is sized with 'weak' PP film former.

Keywords: A. Glass fibers, A. Sizing, B. Interfacial strength, B. Impact behavior, D. Atomic force microscopy

1. Introduction

1.1 Micromechanical characterization of fiber reinforced concrete

In order to improve concrete's performance during impact loading, fibrous reinforcement is used which enhances the adhesion strength and fracture toughness of concrete, as determined by fiber pull-out test