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Influence of Steel Fiber on the Shear Strength of a Concrete Beam

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Abstract

The shear failure in a concrete beam is a brittle type of failure. The addition of steel fibers in a plain concrete mix helps to bridge and restrict the cracks formed in the brittle concrete under applied loads, and enhances the ductility of the concrete. In this research an attempt was made to investigate the behavior and the ultimate shear strength of hooked end steel fiber reinforced concrete beams without traditional shear reinforcement. Four simply-supported reinforced concrete beams with a shear span-to-depth ratio of about 3.0 were tested under two-point loading up to failure. Steel fibers volumetric fractions that used were 0.0, 0.5, 0.75 and 1.0%. Test results indicated that using 1.0% volume fraction of hooked steel fiber led to exclude shear failure and enhanced the use of steel fibers as shear reinforcement in concrete beams. The results also showed that a concrete beam with hooked steel fiber provided higher post-flexural-cracking stiffness, an increase in the shear capacity and energy absorption and an increase in the maximum concrete and steel reinforcement strains.

Keywords: Concrete Beam; Shear Failure; Shear Strength; Steel Fiber; Volume Fraction.

1. Introduction

The prediction of the shear behavior and ultimate shear strength in a steel fiber reinforced concrete (SFRC) beam involves various factors and is complicated. The main parameters involved are the fiber content, fiber geometry, fiber aspect ratio, fiber tensile strength, longitudinal reinforcement ratio shear span-to-effective depth ratio and cement composite properties.

The effects of the shear span-to-effective depth ratio on shear behavior of SFRC beams have been extensively studied by various researchers. To distinguish between short and slender beams, Batson et al. (1972) [1] suggested a critical value for the shear span-to-effective depth ratio of 3.0 for SFRC beams.

Test results indicate that the fibers have significant influence on the mode of failure and ultimate shear strength of a longitudinally reinforced concrete beam [2]. Addition of fibers increased the beam stiffness and ductility, depending upon the shear-span/depth ratio and transformed the mode of failure into a more ductile one [3]. Also, the addition reduced the beam deformations substantially at all load levels, controlled dowel and shear cracking, reduced spalling in the cover, helped to preserve the ductility and overall integrity of the structural member and increased the ultimate shear strength [4].

Steel fiber reinforced high-strength concrete beams effectively resist abrupt shear failure. Such beams exhibit higher cracking loads and energy-absorption capabilities than comparable high-strength concrete beams without fibers [5].

The addition of steel fibers consistently decreased crack spacing and sizes, increased deformation capacity and changed a brittle mode to a ductile one [6]. The addition of fibers in concrete provide an effective crack arresting mechanism and can serve as an energy dissipation methodology in neutralizing seismic forces during earth quakes [7].

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