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Experimental Study for the Effect of Steel Fibers Types and Volume Fraction on the Flexural Performance of RC Beams

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ABSTRACT

This research explores the structural response of reinforced concrete beams (RCBs) enhanced with steel fibers (SFs), focusing on both mechanical strength and flexural behavior. The investigation examined how variations in fiber geometry and dosage affect performance under flexural loads. A series of seven beam specimens, each 20 cm wide, 25 cm deep, and 1.5 m long, were subjected to four-point bending tests. The fibers used included straight, hooked-end, and corrugated types, incorporated at different volumetric ratios. The study also assesses the adequacy of current code predictions in comparison with experimental results. Notably, beams containing hooked-end fibers at a 1% volume fraction demonstrated the greatest performance gains. Specifically, specimens with 3 cm and 5 cm hooked-end fibers exhibited increases in ultimate load capacity of 12.05% and 13.64%, respectively, while deflection capacity increased by 137.83% and 140.73%. The findings reveal that the addition of hooked-end fibers significantly improves flexural strength and ductility. However, existing design models were found to substantially underestimate the ultimate moment capacity. The ACI code predictions were approximately 45% lower, and those of EC2 were about 50% lower than the experimental results. These outcomes indicate the necessity for revision in current design practices to more accurately represent the behavior of steel fiber-reinforced concrete.

1. INTRODUCTION

Concrete that contains short, arbitrarily oriented fibers is known as Fibrous concrete. The main advantage of fibers is the providing of post-cracking tension resistance to the concrete [1-5]. In reinforced concrete structures, cement is a major component, but cement-based material will crack under tensile loading. The remaining strength still exists in RC members before failure, while micro-cracking happens. This problem can be controlled by using fibers. Consequently, numerous researchers have explored the incorporation of steel and plastic fibers into various structural elements and have systematically analyzed their influence on the mechanical properties of these components [6-12]. The spread of cracks can be governed, their initiation can be obstructed, and their width can be reduced by using fibers, as well as, the durability of concrete can be enhanced. Also, concrete's compressive, tensile, and torsion strength can be improved using steel fibers (SFs) [13, 14].

Many researchers investigate the role of steel fibers in the shear and flexural behavior of reinforced concrete (RC) columns and beams. Practically steel fibers reinforced concrete (SFRC) is widely applied in precast tunnel segments, industrial pavements, and slabs [15-19]. Substantial increases in tensile and flexural capacity of SFRC components are generally unachievable with low to medium steel fiber volume fractions. The energy dissipation and toughness in SFRC members can be enhanced using SF [15-19]. Additionally, high SF volume content can increase the tensile strength, Pre-cracking strain-hardening and post-cracking rigidity [20].

Previous studies have thoroughly investigated how SFRC beams respond to four-point bending. According to these tests, Hussain et al. [21] proved that the flexural capacity of RC two-way slabs was improved by 13%, 19%, and 39% for slabs with corrugated SF, polyolefin fiber and hooked end SF, respectively. Whereas, the polyolefin fiber slightly upgrades Concrete’s response to mechanical stress. Abdullah et al. [22] investigate the ability of shape and type of fibers (straight SF, corrugated SF, hooked SF and polyolefin fibers) on the torsional behavior of solid and hollow RC beams. A significant improvement in the torsional capacity was noticed for the beams with corrugated SF, while, the straight SF and polyolefin fibers showed a negligible enhancement in the load-bearing performance and slight improvement in the twisting capacity. However, the polyolefin fibers showed greater capability in improving the twisting deformation capacity of RC beams relative to other types. Altun et al. [23] conducted a laboratory investigation on the demeanor of SFRC BEAMS in flexure; the results showed unimportant enhancement in maximum moment ability and significant improvement in