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Study the Hybridization of Different Fibers on the Mechanical Properties of Concrete: A Mini Review

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ABSTRACT

In recent years, there have been growing interests in utilizing some different fibers in concrete mixes for gaining some advantages from the concept of hybridization of fibers. There are many studies of using mono-fibers such as steel, glass, polypropylene fibers, among others. This review is a trial of showing some highlights for the inclusion of hybrid fibers in concrete mixes and their effects on the different mechanical properties of concrete.

Key words: Hybrid fibers, concrete, mechanical properties, toughness

INTRODUCTION

The main concern about concrete is its brittleness whereas its strength is being increased. Therefore, a higher strength of concrete may lead to a lower in its ductility. This inverse relationship between strength and ductility is a serious drawback when using concrete is of concern. A compromise between these two conflicting properties of concrete can be gained by adding short fibers (Bayramov *et al.*, 2004; Ramli and Dawood, 2011a). The use of steel fiber reinforced concrete might have improved the different mechanical properties of concrete as reported by many researches (Dawood and Ramli, 2010b; Nataraja *et al.*, 1999; Bentur and Mindess, 1990).

Steel fiber has a considerably larger length and higher Young's modulus as in comparison to the other fiber-types. This leads to an improved potential for crack control, although the volumetric density is high. As the result, the steel fiber content has to be reduced to a certain level.

WORKABILITY AND FLOW ABILITY OF FIBER REINFORCED CONCRETE

The use of fibers is well known to affect the workability and the flowability of plain concrete intrinsically (Memon *et al.*, 2006). However, many researchers tried to overcome this problem by using the most workable concrete would be achieved using the optimum aggregate proportions and especially by fixing the optimum content of sand to achieve the best workability as well as, the adding of superplasticizer which can give the concrete high flowability and workability without segregation (Dawood and Ramli, 2010b; Lu *et al.*, 2008; Okamura and Ouchi, 2003; Khayat and Morin, 2002; Rossi and Harrouche, 1990).

However, the effect of using different types of fibers on the flowability or workability of concrete may vary from one type of fiber to another.

Dawood and Ramli (2010a, 2011b) have studied the effect of adding small volume fractions of palm fibers and Barchip fibers with the considerable usual volume fraction of steel fibers on the flowability of high strength flowable mortar. According to them and with a certain amount of superplasticizer in the mix, the inclusion of palm fibers and Barchip fibers may improve the flowability and workability of the mixes and thus, the effect of palm and Barchip fibers on either the flow or working capacity is much smaller than that of steel fiber.

THE EFFECT OF HYBRID FIBERS ON THE PERFORMANCE OF CONCRETE

The compressive strength is one of the most important properties of concrete. The effect of fiber addition on compressive strength ranges from negligible to marginal and sometimes up to 25% as reported by some researchers (Balaguru and Shah, 1992; Dawood and Ramli, 2010b).

The hybridization of fibers can show enhancement in the compressive strength resulted from the better mechanical bond strength between the fibers and the cement matrix which delays micro-cracks formation (Chen and Liu, 2004). The increases in the compressive strength can also be attributed to various restrain conditions which are derived from different types of fibers (Felekoglu *et al.*, 2007).

The other properties of fiber- reinforced concrete which are studied widely by many researchers are the tensile strength and flexural toughness.

The toughness can be defined as a measure of the ability of the material to absorb energy during deformation estimated using the area under the stress-strain curves and thus, it can be considered as the most important properties for fiber-reinforced concrete (Balaguru and Shah, 1992; Dawood and Ramli, 2009).

The enhancements in splitting tensile strength, flexural strength and flexural toughness for the concrete were reported by many researchers (Dawood and Ramli, 2011a; Markovic *et al.*, 2003; Sun *et al.*, 2001; Banthia and Sappakittipakorn, 2007). According to them, the incorporation of two or more fibers may has the bridge the cracks effectively, thus the micro-mechanical features of crack bridging are operative from the stage of damage evolution to beyond ultimate loading. Besides, the hybrid fibers have the ability to arrest cracks at both the micro- and macro-level. At micro-level, fibers inhibit the initiation of cracks. Whereas at macro-level, fibers provide effective bridging and impart sources of toughness and ductility.

According to Bentur and Mindess (1990), the attractive advantages of hybrid fibers systems are:

- They provide a system in which one type of fiber, which is stronger and stiffer, improves the first crack stress and ultimate strength and the second type of fiber, which is more flexible and ductile, leads to the improved toughness and strain capacity in the postcracking zone
- They supply a hybrid reinforcement, in which one type of fiber is smaller, so that it bridges micro-cracks of which growth can be controlled. This leads to a higher tensile strength of the composite. The second type of fiber is larger, so that it can arrest the propagating macro-cracks and can substantially improve the toughness of the composite
- They provide a hybrid reinforcement, in which the durability of fiber-types is different. The presence of the durable fiber can increase the strength and/or toughness retention after certain age while another type is to guarantee the short-term performance during transportation and installation of the composite elements (Qian and Stroeven, 2000)

CONCLUSIONS

The study of the effect of hybridization of different types of fibers on concrete can be considered as a promising work as there is always a need to overcome the problem of brittleness of concrete and the drawbacks of using mono fibers. Therefore, from this review study, it can be seen that the hybrid fibers have proven to be the best solution to improve the different mechanical properties of concrete.

In this study, the researchers concentrated on the most significant effect of incorporating more than one type of fibers in the concrete mixes. The use of mono-fibers which are mainly steel fibers, may face drawbacks such as: inadequate workability, high density and limited enhancement of post-crack zone, among others. Therefore, the concrete mixes can be reinforced with hybrid fibers in order to improve the different mechanical properties of concrete as well as the performance and durability of concrete.

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