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Investigation and comparison of the influence of steel, polypropylene, and korta fibers in improving the flexural performance of reinforced concrete beams

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ABSTRACT: The advantages of reinforced concrete structures, in comparison with other structures, have made concrete one of the most widely used construction materials. However, concrete has brittle performance under flexural loads. Therefore, the present study investigates the influence of different fibers on the flexural performance of large-scale reinforced concrete beams. In order to achieve this goal, four reinforced concrete beams, with similar reinforcement details, measuring 150 cm long, 20 cm wide, and 30 cm high, were made. The beams were reinforced using 0.5% by volume of steel, polypropylene, and korta fibers. Based on ASTM C78, the four-point flexural test was performed and the parameters of flexural strength, energy absorption, ductility, and strain of the rebars were studied. The results indicated that reinforced concrete beam containing steel fibers shows better performance, in terms of flexural strength, energy absorption, and capacity of tensile rebars, in comparison with reinforced concrete beams containing polypropylene and korta fibers. In addition, this study showed that korta fiber reinforced beam has better ductility than polypropylene fiber reinforced beam.

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1- Introduction

One of the weak sides of concrete is its low resistance to bending loads [1, 2]. Researchers in recent decades have used a variety of fibers in concrete to solve this problem [3, 4]. So many studies have reported the positive influence of fibers in enhancing the performance of concrete [5, 6]. One of the most effective fibers in enhancing the mechanical strengths of concrete is steel fibers [7]. However, the positive effect of polymer fibers has also been reported in many studies [8, 9]. Some researchers have suggested the use of fibers as one of the ways to compensate for the loss of strength caused by recycled materials [10]. Therefore, investigating the influence of different kinds of fibers in improving the flexural behavior of concrete beams is the important goal of the present study. Gao and Zhang [11] investigated the effect of 0, 0.5, 1, 1.5, and 2% of steel fibers on the flexural behavior of concrete beams. The results of their research demonstrated that increasing the amount of fibers, leads to increasing the flexural strength of concrete beams significantly. Also, Chaboki et al. [12] investigated the bending performance of beams containing 0, 50, and 100% recycled aggregates and reinforced with 0, 1, and 2% of steel fibers. Their research results revealed that cracking and ultimate moments of recycled concrete beams are less than those of natural concrete beams, which can be increased by using steel fibers.

2- Methodology

2. 1. Materials

Cement

Portland cement type II based on ASTM C150 [13] was used to construct the specimens of the paper. Specific weight and specific surface of cement used were 3.1 g/cm^3 and 3000 cm^2/g, respectively.

Fibers

To reinforce concrete beams, 3 different types of fibers including steel, polypropylene, and Korta fibers have been used. Steel fibers used were the hooked-end type with a diameter of 0.8 and a length of 50 mm long. The lengths of polypropylene and Korta fibers are 12 and 54 mm, respectively.

Steel rebars

All of the steel rebars used in this research were of type AII with diameters of 14 and 10 mm. Direct tensile test was performed on three specimens of each of the rebars, based on ASTM A615 [14] (see Figure 1). The obtained specifications for tested rebars are presented in Table 1.

2. 2. Specimens specifications

In this research 4 concrete beams with length of 150 cm,

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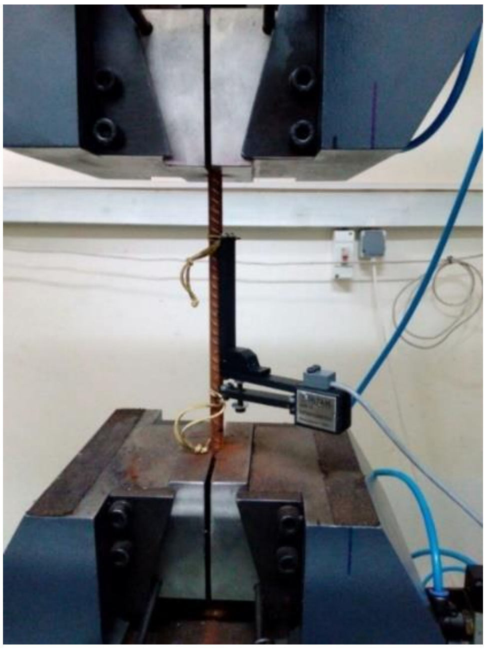

Fig. 1. Tensile strength test of rebars.

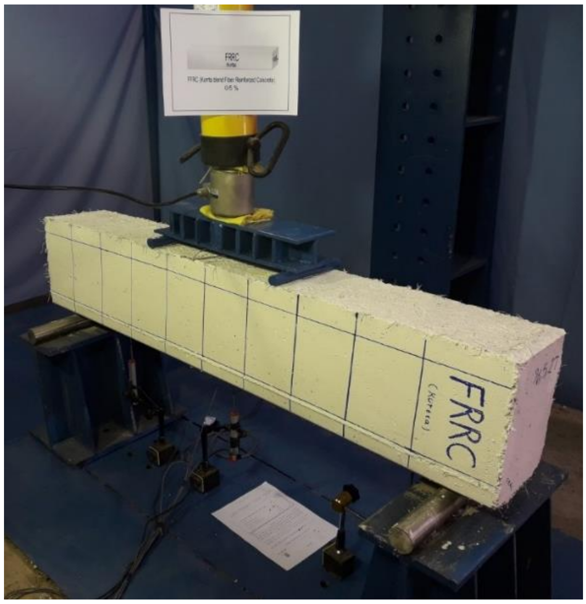

Fig. 2. The beam test setup.

Table 1. Mechanical properties of rebars.

Bar size	E (GPa)	f_y (MPa)	f_u (MPa)
No. 10	207	369.8	562
No. 14	211	293.3	519.9

a width of 20 cm and a height of 30 cm were made. One beam has no fibers called a control specimen, 3 of them contain 1 vol% of steel, polypropylene, and Korta fibers. The longitudinal and transverse bar reinforcement specifications of all beams were the same. All beams were reinforced by 3 longitudinal rebars with a diameter of 14 mm in the tensile zone and 2 longitudinal rebars with a diameter of 10 mm in the compressive zone. The transverse rebars had a diameter of 10 cm and the distances between them were 20 cm.

2. 3. Flexural test setup

The four-point flexural test was carried out on concrete beams after 28 days. The space between the two supports was 130 cm and the distance between the two loading points was equal to one-third of the distance between the two supports. The load on the concrete beam was recorded by a loadcell with a capacity of 500 kN. To measure the deflection of the beams, 10 cm long LVDTs were used. The beam test setup is shown in Fig. 2.

3- Conclusion

1.The addition of fibers increases the compressive strength (up to 10 MPa).

2.Regarding the load of the first crack and the ultimate load, the beam reinforced with steel fibers recorded a better result than the other beams. In the next ranks were reinforced beams with polypropylene and Korta fibers, respectively.

3.In terms of energy absorption, concrete beams reinforced with steel and Korta fibers had the highest final deflection and as a result, compared to other beams, showed the highest energy absorption.

4.Steel and Korta fiber reinforced concrete beams experienced the highest ductility compared to other beams. In the next ranks, respectively, were concrete beam reinforced with polypropylene fiber and the reference beam. Therefore, it can be inferred that fiber-reinforced concrete, due to its inherent nature, namely strain stiffness, has a ductile behavior that this fact was well observed during the tests performed in this study.

5.Tensile rebars of beams with higher bearing capacity, containing steel fibers, entered the plastic stage with higher load bearing. In the next ranks, respectively, concrete beams reinforced with polypropylene, Korta, and reference beam were placed.

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