Experimental investigation of flexural behavior of beams made of fibrous concrete containing natural and recycled aggregates

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ABSTRACT

Given that one of the most concrete and concrete construction materials with suitable compressive strength, ductility, tensile and flexural strength is low. For this purpose, in the past few years by adding fiber to fiber reinforced concrete and concrete construction, greatly improve the weaknesses. The purpose of this study is to investigate the effect of different fibers on the flexural behavior of reinforced concrete beams made with natural and recycled aggregates. In this research, 12 samples of reinforced concrete beams in two groups (6 beams made of natural aggregate and 6 beams made of recycled aggregate) were made in real scale with dimensions of 150×50×20 centimeters, which The reinforcement details of all the beams were the same and three types of steel fibers, polypropylene and Kortta were used separately and hybrid in the construction of the beams. Four-point flexural strength test was performed on the samples. Fracture mode, fracture behavior as well as absorbed energy parameters, ductility and final load capacity of beams made with natural and recycled aggregates were investigated. The results showed that the addition of hybrid fibers had a greater effect on improving the above parameters than separate fibers and also the flexural behavior of recycled samples with hybrid fibers could be closer to natural samples with separate fibers.

Keywords:

Separate fibers, Hybrid fibers, Flexural behavior, Reinforced concrete beam, Recycled aggregate.

1. Introduction

Some research has been done on the use of fibers in concrete and the results of this research show that the mechanical properties of various types of fiber concrete (ordinary concrete, lightweight concrete and high strength concrete) have improved and increased compressive, tensile, abrasion resistance [1-8]. Previous research on the flexural behavior of concrete members with recycled aggregates has shown that the use of recycled aggregates reduces the bending anchorage capacity and increases crack propagation. Steel fibers not only reduce crack formation but also control their growth [9].

Chaboki et al. investigated the effect of using steel fibers in reinforced concrete beams made with recycled aggregate on the flexural capacity and ductility of the beams. They made 27 beams with real dimensions and made concrete materials with 0, 50 and 100 Percentage substitutes also considered the amount of fibers used in the designs as 0, 1 and 2% and also considered the distance of transverse reinforcements as a variable in the research. The results showed that the effect of recycled fibers and aggregates on the ductility ratio and maximum loading capacity depends on other parameters. For example, the effect of steel fibers depends on the distance of transverse reinforcements and the effect of recycled aggregates depends on the

amount of steel fibers and the distance of transverse reinforcements [10].

Taha investigated the flexural behavior of reinforced concrete beams containing recycled industrial waste as steel fibers. He used lathes instead of steel fibers to make reinforced concrete beams. The test results showed that the inclusion of lattice waste significantly improves the strength and deformation properties of concrete. Reinforced concrete beams showed less deformation than conventional reinforced concrete beams. There was a good match between the experimental and numerical results [11].

Therefore, in this research, concretes made of natural and recycled aggregates and adding different fibers such as steel fibers, polypropylene and Kortta have been investigated separately and in combination, and the behavior of reinforced concrete beams on a real scale with aggregates has been investigated. Natural and recycled have been studied. Four-point flexural strength test was performed on 12 beam samples in two groups of natural aggregate (6 beam samples) and recycled aggregate (6 beam samples). In each group, one beam sample was used as a control sample without fibers and 5 beam samples. It contained fibers and in the samples of the two groups, steel fibers, polypropylene and Kortta were used separately and in combination. Fracture behavior as well as parameters of adsorbed energy, failure state, ductility and final load capacity of beams made with natural and recycled aggregates were investigated and compared.

2. Methodology

In this research, 12 samples were made on a real scale and structural with dimensions of 1.5×0.5×0.3 meters. Laboratory fixed parameters of this research include mixing design, sample dimensions and percentage of fibers and variable parameters include the use of different fibers in fiber reinforced concrete and natural and recycled aggregates. A four-point bending test was used for the beams. The loading was static by the hydraulic jack. The amount of displacement of the loaded sample was controlled and recorded by the displacement gauges placed below the sample. It should be noted that the hydraulic jack was connected to the load gauge and the load of the jack was sent to the data stabilization device and read. At the connection of the jack to the load gauge and the load gauge to the load beam, a fiber coating was used to reduce the error and noise of the data in the metal-to-metal connection. The data were sent and the time of their submission was extracted according to the results of the direct tensile test of the rebar.

3. Results and Discussion

3. 1. Compressive strength

Figure (1) shows the compressive strength diagram of hybrid and separate fiber samples for samples with natural and recycled aggregates. Also in this diagram, the amount of increase in compressive strength of fibrous samples compared to the reference sample without fibers is compared. As can be seen in this figure, the use of fibers increased the compressive strength of the samples. In both natural and recycled samples, the highest amount of compressive strength increase compared to the reference sample, related to the sample containing hybrid fibers. Steel and Kortta and the lowest increase was observed for the sample containing separate polypropylene fibers. The amount of increase in compressive strength of the samples compared to the reference sample of 31, 28, 19, 4 and 1% for samples with natural aggregates and 22, 17, 8, 5 and 1% for samples with recycled aggregates, respectively, related to Steel and Kortta hybrid samples, separate steel fiber samples, steel and polypropylene hybrid fiber samples, Kortta separate fibers and separate polypropylene fibers were recorded.

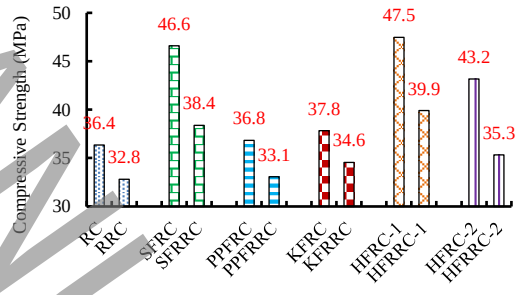

Fig. 1. Compressive strength of concrete specimens containing natural and recycled aggregates with separate and hybrid fibers

3. 2. Load– displacement diagram

Figure (2) shows a load-displacement diagram in the middle of the beam for six samples with recycled aggregate.

Figure (2) shows that in beams made with recycled aggregate, the amount of strength increase and bearing capacity of HFRRC-1 beam has the highest value and in the next categories, HFRRC-2, SFRRC, KFRRC beams, respectively. And PPFRRC and their increase in resistance to RRC beams is 88, 64, 31, 17 and 14%, respectively. In both natural and recycled groups, beams

containing polypropylene fibers showed the lowest amount in this regard.

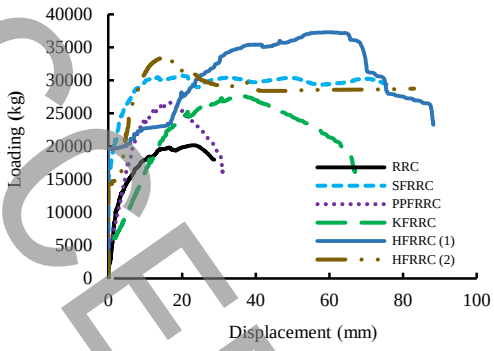

Fig. 2. Comparison of load-displacement diagram in the middle of the span, in reinforced concrete beams containing recycled aggregate with separate and hybrid fibers.

In terms of ductility, as shown in Figure (15-b), in beams containing recycled aggregate, the amount of ductility of HFRRC-1 beam had the highest value, and in the next categories, HFRRC-2 beam, respectively. SFRRC, KFRRC and PPFRRC are found and the amount of increase in ductility for the recycled group, hybrid fiber beams about 2 times and steel fiber beams about 1.8 and Kortta fiber beams about 1.4 times compared to RRC beams were obtained. In both groups of beams with natural and recycled aggregate, polypropylene fiber beams had a slight increase compared to the reference beam.

4. Conclusion

In this study, to investigate the behavior of concrete beams made of natural and recycled aggregates and by adding different fibers, 12 beam samples were made in real dimensions and tested. The following results obtained from this research are presented as follows:

1- In all fiber samples compared to the reference sample due to the addition of fibers, compressive strength has increased and the highest increase is related to the hybrid sample of steel and Corta and the lowest is related to the sample of polypropylene fibers.

2- The amount of energy absorption of the beams in both the group of beams with natural aggregate and the group of beams with recycled aggregate, the highest value was related to the beams containing hybrid steel and Kortta fibers and the lowest value was related to the beam containing separate polypropylene fibers.

3- Among the pairs of similar natural and recycled samples from both groups, samples made of natural aggregates recorded load-bearing capacity, final rise and higher energy absorption, and also in terms of flow of tensile rebars, among pairs of similar samples, samples The natural ones gave in more load and entered the plastic area.

References

[1] Altun F., Haktanir T., Ari K., Effects of steel fiber addition on mechanical properties of concrete and RC beams, Construction Building and Materials 21 (1) (2007) 654–661.

[2] Gao J., Sun W. and Morino K., Mechanical Properties of Steel Fiber-Reinforced, High Strength, Lightweight Concrete, Cement and Concrete Composite, 19 (1997) 307–313.

[3] Marar K., Eren Ö. and Yitmena I., Compression Specific Toughness of Normal Strength Steel Fiber Reinforced Concrete (NSSFRC) and High Strength Steel Fiber Reinforced Concrete (HSSFRC), Materials Research, 14 (2011) 239-247.

[4] Song S., Wu C. and Hwang S., Mechanical Properties of High Strength Steel Fiber Reinforced Concrete, Construction and Building Materials, 18 (2004) 669-673.

[5] Eren Ö. and Çelik T, Effect of Silica Fume and Steel Fibers on Some Properties of High-Strength Concrete, Construction and Building Materials, 11 (1997) 373-382.

[6] Yazici S., Inan G. and Tabak V., Effect of Aspect Ratio and Volume Fraction of Steel Fiber on the Mechanical Properties of SFRC, Construction and Building Materials, 21 (2007) 1250-1253.

[7] Tanoli W., Naseer A. and Wahab F., Effect of Steel Fibers on Compressive and Tensile Strength of Concrete, International Journal of Advanced Structures and Geotechnical Engineering, 3 (2014).

[8] Ahmed Tareq Noamana, Abu Bakar B.H. and Hazizan Md. Akil., Effect of curmb rubber aggregate on toughness and impact energy of steel fiber concrete, PhD of engineering, Civil Eengineering, Universiti Sains Malaysia, (2016).

[9] W.J. Weiss, S.P. Shah, Recent trends to reduce shrinkage cracking in concrete pavements, in: Proceedings of the Airfield Pavement Conference, Aircraft/Pavement Technology: In the Midst of Change, (1997) 217–228.

[10] Chaboki H. R., Mansour Ghalehnovi M., Karimipour A., Jorge de Brito, Experimental study on the flexural behaviour and ductility ratio of steel fibres coarse recycled aggregate concrete beams, Construction and Building Materials, 186 (2018) 400–422.

[11] Taha A. El-Sayed, Flexural behavior of RC beams containing recycled industrial wastes as steel fibers, Construction and Building Materials 212 (2019) 27–38.