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Experimental Evaluation of Structural Performance of FRC Beams with Hooked Metal and Macro Polymer Fibers at Different Levels of Reinforcement Corrosion

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ABSTRACT: Corrosion in reinforced concrete structures reduces the strength capacity and ductility of members and concrete elements. The use of fibers to improve the mechanical properties of concrete has long been considered by engineers. In this study, an experimental study was conducted to investigate the effect of macro-polymeric fibers and hooked metal fibers on corrosion-free, non-corrosive reinforced concrete beams. Two types of macro-polymeric fibers and hooked metal fibers with 0% and 0.5% volume percentages were tested at three levels of corrosion of 0%, 7%, and 9%. An accelerated corrosion test was used from a 3% salt pool. Finally, the reinforced concrete beams were subjected to bending loading tests. Structural behavior of reinforced concrete beams in corrosion beams and non-corrosion beams and with fibers and non-fibers were evaluated and compared. Based on experimental results, corrosion reduces the ductility of the specimens and the use of metallic and polymeric fibers in non-corrosion and corrosion specimens of the first and second surfaces causes a two-fold increase in ductility. Macro polymer fibers are more effective in increasing the shape of the samples compared to the hook metal fibers in corrosion samples. Increasing the percentage of corrosion in non-fibrous specimens decreased the maximum resistance of the specimens, but in specimens with fibers, no significant change was observed in the bearing capacity of the samples with increasing corrosion percentage.

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1. Introduction

Corrosion of rebar in concrete is one of the most important causes of structural and functional damage to reinforced concrete structures [1]. Chloride penetration into the concrete or carbonation and lowering of the pH of the concrete environment, if appropriate, lead to corrosion of the reinforcement and can reduce the cross-sectional area of the longitudinal and transverse bars. While the cross-section of the bars is reduced due to corrosion, the corrosion products around the bars cause a large volume expansion in the concrete. Oxidation of iron and its conversion to soluble oxides also called rust, and the accumulation of this oxide around the rebar causes internal pressure in the concrete and damages the concrete cover (even when corrosion occurs uniformly) [2]. The effects of corrosion on the mechanical properties and behavior of concrete structures can be attributed to the influence of corrosion on the ductility, strength capacity, stiffness, and crack pattern formed in concrete samples. Fig. 1 shows an example of damage to concrete members and elements due to corrosion of longitudinal and transverse reinforcement.

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Fig. 1. Damage to concrete members due to corrosion of reinforcement

The use of metallic and polymer fibers has been widely used to improve the mechanical properties, especially in improving flexural strength as well as to control the crack width of the beams in the building industry. The most common type of fiber to improve structural performance is steel floor. The other type of fiber is polypropylene fiber type which can reduce plastic crack in the concrete.

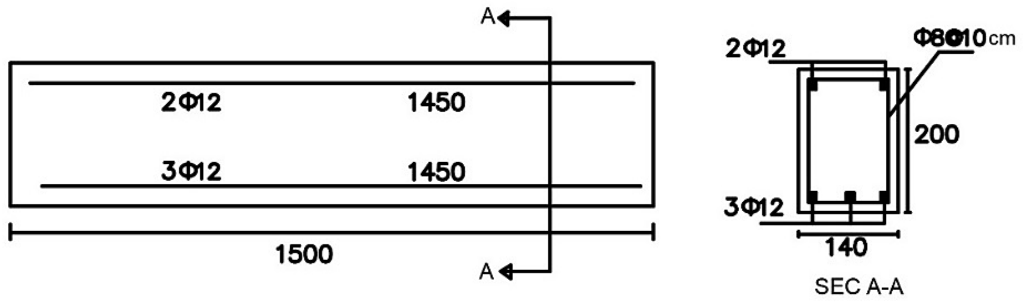

Fig. 2. Geometric details and reinforcement of beams specimens (Dimension in millimeters)

Although many studies have been done on the effect of using different fibers on concrete specimens, the comparative effect of macro polymer fibers and hooked metal fibers on specimens of large size, close to real, and with corrosion have been not done yet. In this study, the effects of both types of macro and metal polymeric fibers on full-scale concrete samples at different levels of corrosion were investigated to investigate the flexural strength, ductility, and crack pattern. Because the focus of this study was on large, near-realistic specimens, the authors attempted to create accelerated corrosion conditions at various levels so that both longitudinal and transverse bars are uniformly affected by corrosion under Faraday's law. In this study, the effect of two types of macro polymer and hooked metal fibers with different volume percentages by constructing nine reinforced concrete beams with a cross-section of 200 * 140 mm and a span length of 1500 mm in Shahrood University of Technology Structural Laboratory have been investigated. Two volumes of fiber including 0% and 0.5% were tested at three levels of corrosion level of 0%, 7%, and 9%. A pool of 3% salt was used for accelerated corrosion testing. Finally, reinforced concrete beams were subjected to bending loading and load-displacement curves of different specimens compared based on the experimental results including, strength, stiffness, and ductility of specimens.

2. Experimental program

In this study, two types of hooked metal fibers and macro polymer fibers were tested in concrete beam specimens and examined at different levels of corrosion. The samples were divided into three main groups A, B, and C. Group A had 0% corrosion samples, Group B had 7% corrosion samples and Group C had 9% corrosion samples. Each group was again subdivided into three subgroups without fiber, samples with hooked metal fibers and samples with macro polymeric fibers. The cross-sectional area of the concrete beam is 200 x 140 mm and its span is 1500 mm. The concrete cover is 25 mm from the concrete surface to the transverse bars. The longitudinal bars are 12 mm in diameter and the transverse bars are 8 mm in diameter with a distance of 10 cm. Laboratory specimens with 1.2 transverse scale and 1.4 longitudinal scales were constructed at Structural Laboratory, Faculty of Civil Engineering, Shahrood University of Technology. Fig. 2 shows the reinforcement details of the specimens.

Fig. 3. View of test setup

3. Material Properties and test setup

The concrete mix was composed of materials that were locally available. All test specimens were constructed using normal weight and ready mixed concrete with a targeted 28-day concrete compressive strength of 26 MPa and concrete specified slump of 100 mm, with a maximum aggregate size of 19 mm.

the yield strength of the steel reinforcement for 8 mm and 14 mm diameters was 388 MPa and 479 MPa, respectively. View of test setup is shown in Fig. 3.

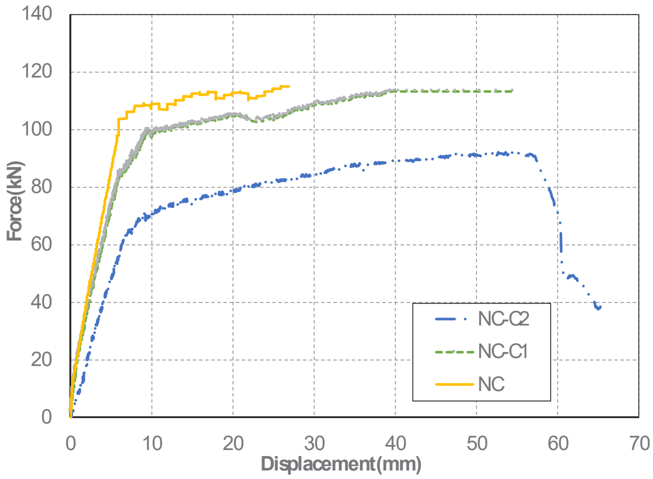

Fig. 4. Load-displacement curve of corroded (5% & 7.2%) and non-corroded beams without fiber

a) Specimen NC-C2

b) Specimen NC-C1

c) Specimen NC

Fig. 5. Final failure pattern of specimens at different levels of corrosion

4. Test results and discussion

Load-displacement curve of corroded (5% & 7.2%) and non-corroded beams without fiber is shown in Fig. 4.

The final failure pattern of specimens at different levels of corrosion is shown in Fig. 5.

5. Conclusions

In this paper, an experimental study was conducted to investigate the effect of reinforcement corrosion on the behavior of fiber-reinforced concrete beams with hooked metal and macro polymer fibers. According to the laboratory observations, the most important results of this study are as follows.

1) Using fibers, the ductility was significantly increased and the ductility increased with respect to the specimens using macro polymer fibers compared to the specimens using hooked metal fibers.

2) Based on the experimental results, it was found that the effect of fiber on the structural performance of RC beams to improve the ductility has decreased and decreased with increasing corrosion percentage. However, corroded beam specimens made of fiber concrete had even better performance than non-fibers and non-corroded specimens at the highest corrosion rate (7.2%).

3) Increasing the percentage of corrosion in non-fibrous specimens decreased the maximum resistance of the specimens, but in specimens with fibers, no significant change was observed in the bearing capacity of the samples with increasing corrosion percentage.

4) Due to the density of the macro polymer fibers and hence the need to use less fiber in a given volume than hooked metal fibers (0.5% in the specified volume) these fibers can be more economical, more durable than metal fibers.

References

[1] W. Zhu, R. François, Corrosion of the reinforcement and its influence on the residual structural performance of a 26-year-old corroded RC beam, Constr. Build. Mater. 51 (2014) 461–472.

[2] A. Hosseini, T. Parhizgar, Extraction of concrete chlorase ion to stop corrosion of reinforcement, BHRC, 1384

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