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The effect of steel and hybrid fibers on the impact resistance of concrete enclosed with FRP sheets

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Abstract

Due to the widespread use of concrete in all kinds of structures, the probability of its exposure to dynamic loads has increased. Since concrete is one of the most widely used materials in civil engineering, its main weakness can be pointed out, which is its brittleness and brittle performance. The use of fibers to improve the properties of concrete has been the focus of engineers for a long time. The most common fibers used to increase the impact resistance of concrete, steel and polypropylene were investigated in this research as single and hybrid fibers. In this study, by using the ACI 544-based weight projection method, the resistance of concrete against impact loading on standard cylindrical concrete samples (30 x 15) containing steel fibers and polypropylene in two cases with and without lap sheet FRPs were investigated. The results showed that the use of these fibers increases the impact resistance of concrete. Also, both CFRP and GFRP sheets that were tested improve the impact resistance of concrete and increase the number of cycles of this test. Some GFRP sheets have performed better than CFRP. Also, the presence of FRP sheets has caused a change in the type of failure compared to the absence of FRP. Also, concrete samples whith fiber delay concrete breaking, significantly. (DOI:**https//doi.org/10.52547/JCER.4.2.41**)

Keywords: Concrete, Impact resistance, Steel Fibers , Hybrid fibers , FRP sheets ;

1. Introduction

Concrete is one of the most widely used construction materials, as it is used in various construction activities such as roads, dams, tunnels, buildings, etc. With the increase in the use of concrete, the possibility of being exposed to various loads, including static and dynamic loads, has also increased. Types of dynamic loads can include earthquakes, explosions, wind, etc. To determine the resistance of concrete against such loads, different methods have been presented [1]. One of the most common, least expensive, and at the same time the

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simplest method is the weight throw method proposed by the ACI 544 [2] committee. This study tries to investigate the behavior of concrete samples after being subjected to impact load by the drop weight throwing method. All kinds of dynamic and static loads can cause cracks in the structures that all kinds of load-bearing elements of concrete structures are covered by FRP sheets for strengthening, it is customary that the reason is the delay in placing the damaged concrete member in the final rupture range. is. As the aim of this study, the effect of wrapping concrete samples containing steel and hybrid fibers by CFRP and GFRP sheets on the impact resistance of concrete has been investigated. For this purpose, concrete samples were made with a water-cement ratio of 0.34 and its impact resistance was investigated with and without CFRP and GFRP screws**.**

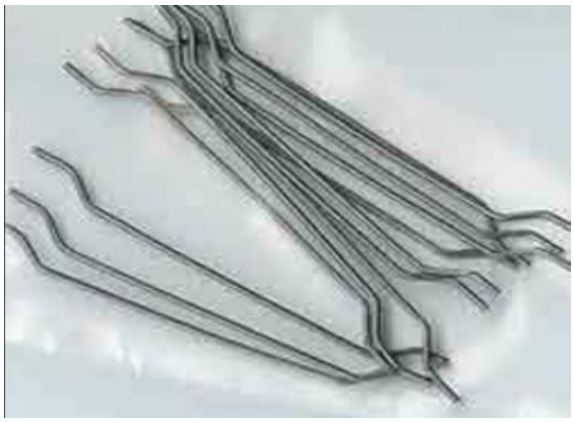


Figure 1. Steel fibers & [4].

Figure 2. Polypropylene fibers[4].

2. Mixing proportions

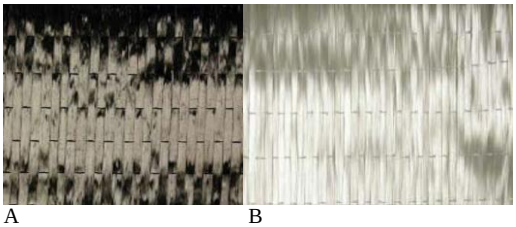
2.1. Consumable materials

In this study, type 2 Portland cement was used as an adhesive material. Its related chemical compounds are available in Table 1. River type sand and broken type sand with the largest nominal size of 12.5 mm and water absorption percentage of 0.73. Also, steel and polypropylene fibers have been used in concrete samples in a single and hybrid form. In the following, two types of CFRP and GFRP sheets are used to cover the samples under loading in order to delay the failure.

Table 1

Characteristics of used fibers[4].

Type of fiber	Density (gr/cm^3)	Tensile strength (Mpa)	Diameter (mm)	Length (mm)	Aspect ratio	Modulus of elasticity (Gpa)
Steel	7.8	1050	0.75	60	80	210
Polypropylene	0.91×10^{-3}	350-400	0.022	12	545	4



A B

Figure 3. A CFRP & B GFRP sheet.

Table 2
Chemical properties of used cement[4].

Chemical compounds(%)	Cement
SiO_2	46.21
Al_2O_3	55.5
Fe_2O_3	46.3
CaO	95.63
MgO	86.1
SO_3	42.1
K_2O	54.0
Na_2O	26.0

2.2. Plans for mixing concrete and preparing samples

In this article, normal concrete samples were made with a water-cement ratio of 0.34. After making the concrete, 10 cm cubic samples were molded to perform the compressive strength test. The compressive strength was tested on the samples at the age of 28 days. Also, cylindrical standard samples of 15 x 30 cm were made to determine the impact resistance. As shown in Figure 1, to perform the impact resistance test from a hammer weighing 4.45 kg that is free-falling from a height of 7.45 cm on a steel sphere with a diameter of 6.35 cm exactly on the center of the sample. It was used as a ring (15x6.4) cm. According to the ACI 544 committee, this ball is inside a piston that prevents the ball from moving out of the center of the concrete. The significant point is that the blows must be applied to the sample completely consecutively, and also in the concrete under test, the grading and description of the aggregates must be the same so that we can have good results. By definition, the minimum number of blows to create the first visible crack is represented by N1, and the number of blows for final failure is represented by N2.

Figure 4. A device for determining impact resistance based on ACI 544

3- results

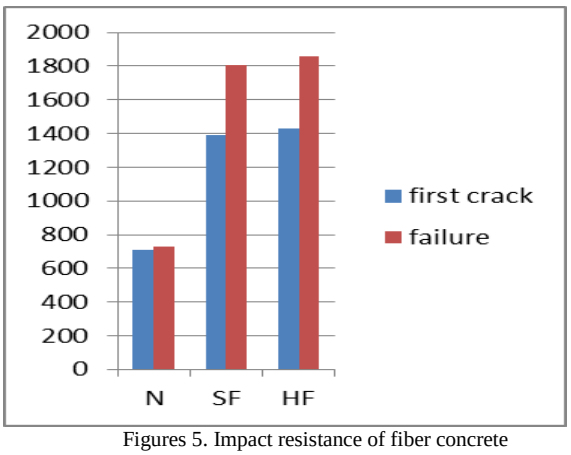
The compressive strength of ordinary concrete with steel fibers and hybrid with a water-cement ratio of 0.34 at the age of 28 days has been calculated, which is based on the average of three cubic samples of 10 cm. The concrete containing 1% steel fibers was tested, the compressive strength of this concrete was 61.7 MPa, compared to concrete with the same structure without fibers, this concrete showed an increase in strength by 10% and 6%, respectively. Also, the concrete containing the combination of steel fibers and polypropylene was investigated and its compressive strength was 59.1 MPa, the results showed that compared to the normal concrete, the strength increased by 7.2%, but compared to the concrete with 1% steel fibers, 3. It has shown an 11% decrease in resistance. These results show the high ability of steel fibers to control cracks and breakage

during load application type of concrete can be divided into high strength concrete. The impact resistance of concrete samples with and without screws and of CFRP and GFRP types was investigated, and the results are shown in Figures 2 and 3 for the first visible crack and final failure, respectively. As it can be seen, the first crack in fiber concrete without laps occurred in 1731 blows. This amount of impact in the presence of GFRP screws has been obtained in the amount of 3106 impacts. Such a situation in the presence of CFRP laps has an increase compared to concrete without laps. According to the results, it can be pointed out that the performance of FRP wrapped concrete against impact loads has improved .The final impact resistance of fiber concrete with 1832 round screw is estimated, which is about 101 impacts more than the number of impacts required for the first crack.

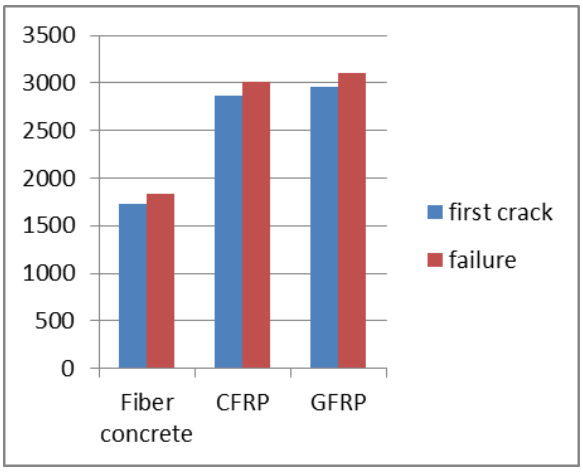
Table 3

28-day compressive strength of concrete

Type of fiber	Design type	Compressive strength (Mpa)
1	NC	54.8
2	ST **(ST1)**	61.7
3	HF **(ST1PP0.1)**	559.1



Figures 5. Impact resistance of fiber concrete



Figures 6. Impact resistance of concrete wrapped with FRP sheets

In a study by Nili and Afroughsabet [3], this number for normal concrete is 3 impacts. On the other hand, the ultimate strength of concrete wrapped with GFRP is 3106 blows, which is 152 blows more than the first visible crack.

Figures 7. Failure method in samples a. without winding , b. GFRP & c. CFRP

4 - Conclusion

In this study, the effect of CFRP and GFRP sheets on the resistance of concrete containing steel and hybrid fibers against impact in cases with concrete without laps has been investigated, and the following results were obtained.

1. The results showed that the use of steel and hybrid fibers were effective in increasing the impact resistance of concrete, but hybrid fibers could have a greater effect in controlling cracks and final failure in concrete.
2. The presence of GFRP screws increases the impact resistance of concrete without screws up to 1.7 times.

This situation is increased up to 1.64 times in the presence of CFRP screws.
3. The presence of both GFRP and CFRP laps improves the final rupture strength compared to concrete without laps.
4. Rounding can not only increase impact resistance, but can also increase the number of concrete blows between the first crack and the final crack, which will have afavorable effect on the design and performance of the structure.
5. Wrapping concrete by FRP sheets causes crack control and wide microcracks.

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