Journal of Ferdowsi Civil Engineering, Vol.32, No.3, 2019.

Investigation of Mechanical and Impact Properties of HPSC Composite Concrete

Amir Hossein Sahraei Moghadam[1]
Fereydoon Omidinasab[2] Ahmad Dalvand[3]

1. Introduction

A concrete is the most widespread material in civil engineering, and due to its technical and economic advantages, it has gained widespread acceptance in various structures, although it suffers from disadvantages such as brittleness, and poor performance, particularly, under impact and tensile loads. In order to improve the mechanical properties of concrete, and in order to increase its capability for energy absorption and impact resistance, researchers have recently focused on the use of natural and artificial fibers. Self-compacting concrete was first introduced in 1988 as a durable type of concrete suitable for being used in structures. Early studies on the self-compacting concrete were conducted by Ozawa in 1989 and by Okamura in 1993 at the University of Tokyo. Self-compacting concrete is a type of concrete which flows under its own weight without needing any vibration, fills the mold, and keeps its homogeneity. Results of the previous studies show that the plain concrete is weak under the impact and flexural loads. It is very effective to use natural and artificial fibers in order to increase the concrete strength for the flexural and impact loads. During the last three decades, many studies have been conducted on the effects of steel fibers as they contribute to the mechanical properties and impact resistance of concrete. Previous studies show that steel fibers can considerably improve the mechanical properties and impact strength of concrete. The application of different fibers can enhance the concrete strength under dynamic loads. Adding fibers to concrete can increase the energy absorption and can improve the impact resistance of concrete, and it can prevent the cracks from spreading. Moreover, short and separate fibers can delay the distribution of cracks resulting from impacts/blows. This is due to the fact that fibers play the roles of bridges over cracks, thereby stopping their further spread. Fibers bridging over the cracks will consolidate the concrete and will increase the flexural and tensile deformations. Soroushian, Ataullah and Hsu (1992) showed that the addition of fibers could increase the first-crack resistance and the ultimate resistance in the impact test more effectively, as compared to its effects on the flexural strength.

2. Experimental Program

To make the specimens, the Portland cement, Type 2, was used in accordance with the ASTM C150 Standard. The present study used the hooked-end steel fibers measuring 50 mm long and 0.8 mm thick. Figure 1 shows the photographs of steel fibers and Table 1 shows the properties them. All the aggregates passed through No. 8 sieve, with the specific weight being 2.6 (gr/cm^3). In order to achieve the required workability, the researchers used Dezobuild 10, a commercial carboxylate superplasticizer, for making the concrete. Table 2 shows the concrete mixed design used for constructing the specimens. The mixed design used for making all the specimens contained the same volume of aggregates, cement, water, and superplasticizer, with the specimens being different in terms volume of fibers and slabs thicknesses. The present study made 27 slabs reinforced with steel fibers, measuring 400×400 cm, with three different thicknesses including 2.5, 5 and 7.5 cm in 9 different models (3 specimens for each model). Among the 9 models, 3 models did not contain fibers and were used as the control specimens, other models contained a 0.5% and 1% volume of fibers. All the specimens were kept at 25°c and 85% RH for 24 hours. Then, the specimens were cured for 28 days in water tanks of 20°C. After 28 days, the specimens were tested.

Fig. 1. Steel fibers

Table 1. Properties of steel fibers

Fiber	Length (cm)	Diameter (cm)	E (GPa)	Tensile strength (MPa)
Steel	5	0.08	200	1100

Table 2. Mix design used.

Sand (kg/m^3)	**Cement (kg/m^3)**	**W/C**	**Water (kg/m^3)**	**SP (kg/m^3)**
1006	1006	0.38	383	**4.8**

3. Test procedure

The compressive strength test was performed on cube specimens with side lengths of 100 mm in accordance with the ASTM C39 Standard with a loading rate of 0.3 MPa/s. Splitting tensile strength test, in accordance with

[1] M.Sc. Civil Engineering, Lorestan University, Khoramabad, Iran.
[2] Corresponding Author: Assistant Professor, Faculty of Engineering, Lorestan University, Khoramabad, Iran.
Email: omidinasab.f@lu.ac.ir
[3] Assistant Professor, Faculty of Engineering, Lorestan University, Khoramabad, Iran

the ASTM C496 Standard, was performed on the cylinder specimens with 100 mm of diameter and 200 mm of height at a loading rate of 0.05 MPa/s. The three-point bending test (the application of a concentrated load at mid-span), in accordance with the ASTM C1016 Standard, was performed on 15 bending beams measuring 320 mm long, 60 mm wide, and 80 mm high. In ultrasonic pulse velocity (UPV) test was performed on cube specimens with side lengths of 100 mm in accordance with the BS 1881 Standard with the direct method (that is, placing the transducer on both sides of the cubic specimen) has been used. In the impact resistance test, 27 slabs reinforced with steel fibers, measuring 400×400, with three different thicknesses including 2.5, 5 and 7.5 cm were investigated under the drop weight impact effects. Fig. 2 shows the drop weight impact testing machine. By means of a steel cable installed on a pulley, the testing machine used a steel ball weighing 5.8 kg. By means of the steel cable and the pulley, the ball repeatedly went up to the height of 1.5m and dropped onto the specimens. This continued up to the moment of failure development in slabs. To guarantee that the ball would precisely hit the slab center, a guiding system was used for the ball, which consisted of a cube and a plastic pipe. In this test, the number of blows required for the development of the first visible crack and for the slab destruction was recorded.

Fig. 2. Test setup of drop weight impact

4. Conclusion

The present study deals with the impact strength of concrete slabs by means of low-speed impact test (drop weight impact test). The present study mainly aimed to improve the impact behavior of slabs by increasing the slabs thicknesses and addition steel fibers. In order to improve the impact resistance of slabs, therefore, the volume of fibers used in slabs was 0.5% and 1%, and thickness slabs was considered 2.5, 5, and 7.5 cm. The drop weight impact test measured the parameters of first-crack strength, failure strength, and absorbed energy. Results of the drop weight impact test showed the considerable role the steel fibers can play to increase the impact resistance of slabs. In this test, the fiber-free slabs showed a brittle behavior since they reached failure and were fragmented immediately after the first crack development. However, the slabs containing steel fibers could endure many blows after the first-crack development up to the moment of failure. This shows that steel fibers can effectively increase the consolidation and/or resistance of specimens. Fig. 3 shows the difference of failure mode of the plain and RC slabs. Impact test results showed that the role of addition of steel fibers in increasing the slab resistance was much more significant than the increasing slabs thickness.

Fig. 3. Failure mode in plain concrete slabs and RC slabs under drop weight impact