HBRC Journal (2016) **12**, 54–62

Housing and Building National Research Center

HBRC Journal

http://ees.elsevier.com/hbrcj

Behavior of hybrid high-strength fiber reinforced concrete slab-column connections under the effect of high temperature

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Received 11 November 2015; revised 21 January 2016; accepted 24 January 2016

KEYWORDS

Elevated temperature;
Hybrid concrete;
Polypropylene fibers;
Cracking;
Steel fibers

Abstract Concrete can be modified to perform in a more ductile form by the addition of randomly distributed discrete fibers in the concrete matrix. The combined effect of the addition of two types of fibers (steel fiber and polypropylene fiber with different percentages) to concrete matrix, which is called hybrid effect is currently under investigation worldwide. The current research work presents the conducted experimental program to observe the behavior of hybrid high strength reinforced concrete slab-column connections under the effect of high temperature. For this purpose, ten slab-column connections were casted and tested. The experimental program was designed to investigate the effect of different variables such as concrete mixture, column location and temperature fighting system. All specimens were exposed to a temperature of 500 °C for duration of two hours. To observe the effect of each variable, specimens were divided into four groups according to the studied parameters. The test results revealed that using hybrid high strength concrete HFHSC produced more strength in punching failure compared with high strength concrete HSC when exposed to elevated temperature. Fighting by air had higher initial crack load compared with that for without fighting and fighting by water. On the other hand, fighting by water decreased the ultimate load.

Introduction

Hybrid fiber concrete is made in order to achieve balanced improvement in the performance of concrete. Since concrete is a relatively brittle material, addition of fibers makes it more homogeneous and isotropic and transforms it from a brittle to a more ductile material. The basic purpose of using hybrid fibers is to control cracks at different size levels, in different zones of concrete (cement paste or interface zone between

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Peer review under responsibility of Housing and Building National Research Center.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.hbrcj.2016.01.007
1687-4048

paste and aggregate), at different curing age and at different loading stages. The large and strong fibers control large cracks. The small and soft fibers control crack initiation and propagation of small cracks [1,2].

Hassan [3], concluded that high strength concrete has more resistance than normal concrete slab specimens when exposed to high temperature. Cooling the specimens by water caused a reduction in failure load and cooling by air is less effective than cooling by water.

Mazaheripour et al. [4], showed that Polypropylene (PP) fibers did not affect the compressive strength, but applying these fibers at their maximum percentage volume increased the tensile strength by 14.4% in the splitting tensile strength test, and 10.7% in the flexural strength. The authors [5–7] concluded that the addition of polypropylene fibers decreased spalling in HSC members under fire conditions.

The presence of PP fibers was more effective for compressive strength than splitting tensile strength above 200 C. Moreover, the splitting tensile strength of concrete was more sensitive to high temperatures than the compressive strength [8–11].

Using steel fibers increased the resistance of the composite reinforced with randomly distributed short carbon fibers and vice versa. The steel fibers were better utilized [12,13].

The addition of hybrid fibers to high strength concrete improved the first crack stress and ultimate strength, and leads to the improved toughness and strain capacity in the post-cracking zone. Used hybrid reinforcement, of small fiber, makes bridges micro-cracks of which growth can be controlled. This leads to a higher tensile strength of the composite. Also, the presence of the durable fiber can increase the strength and/or toughness retention after certain age [14,15].

Zeiml et al. [16] reported that spalling occurs when the permeability of the dry zone (a region without liquid water) of the concrete member is not sufficient to avoid a continuous pressure buildup as a consequence of vaporization of evaporable water. They presented an illustration of spalling based on the results of same work [17–19] as shown in Fig. 1.

Research significance

The main objective of this research was to investigate the effect of high temperature on hybrid high strength reinforced concrete slab-column connection under the effect of axial load.

Experimental program

The current experimental program is conducted to investigate the effect of elevated temperature on hybrid fiber slab-column connections. Tests were carried out on ten specimens divided into four groups to study the effect of mixture type, column location and temperature fighting system. All slabs were exposed to constant temperature of 500 °C for two hours. All specimens were tested just after removal of oven except specimens S9 and S10 were cooled by air and by water, respectively, before testing. Table 1 shows the specimen's details.

Test specimens

Test specimens represented eight interior slab-column connections and two exterior slab-column connections. The slab part is assumed to be bounded by the line of contra flexure around the column. Slabs have a square shape of 1100 mm side length and 100 mm thickness. Columns have square cross section of 150 mm side length and 400 mm height above the slab. All slabs were provided with tension reinforcement of 11Ø10 and compression reinforcement of 7Ø10. All column stubs

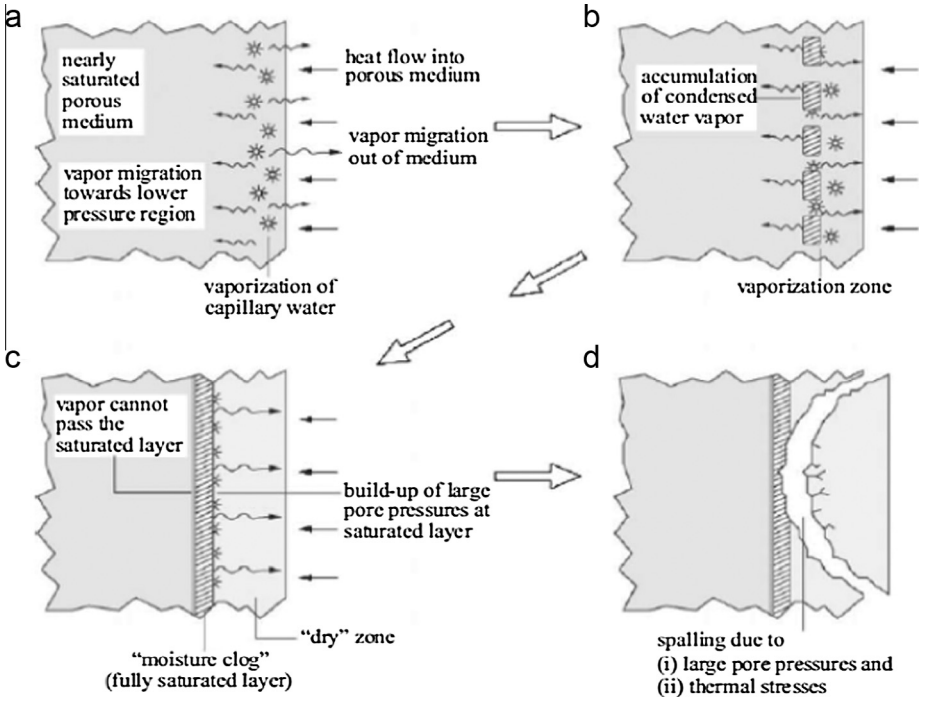

Fig. 1 Proposed mechanism of spalling of concrete subjected to fire [16–19].