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EXTENDED ABSTRACT

Experimental Strengthening of Deficient RC Beams with Advanced HPFRCC Composite Layers Reinforced with PP Fibers

Mohammad Kazem Sharbatdar*, Mehdi Ahmadpanahi

Faculty of Civil Engineering, Semnan University, Semnan, Iran

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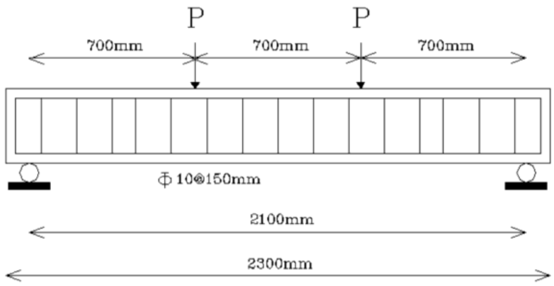
1. Introduction

The old existing structures and design and construction deficiency are the main to concentrated on using high-performance fiber composite HPFRCC for strengthening, Nowadays. Because of increasing demands in the construction industry, it is required to use new materials of high quality in this regard. Therefore based on necessities in our country for having high-performance composite materials such as HPFRCC, these materials are spreadly used as strengthening materials. The main research issues in this regard are composite ingredients and design mixes, stress-strain curves, and material behavior. Even though some structural applications are conducted on HPFRCC material (Alwan, 1994; Naaman, 2005), it is required to perform new experimental and analytical researches on material mixes with different fibers, and percentages and flexural behavior of reinforced concrete specimens strengthened with this material and their durable performance (Hemmati, 2016; Ehsani, 2019). The effect of structural performance and different arrangements of new material layers of this advanced material on five strengthened reinforced concrete beams was experimentally investigated in this paper, and their results were compared to each others.

2. Experimental study

The beams consisted of one Reference un-strengthened RC beam, and four others strengthened with PP fiber HPFRCC layers with two different materials and two different methods installed in-cast on the bottom face of the RC beam. Two different concrete mixes with 0.5 and 0.6 water to cement ratios were used for retrofitting deficient beams. Propylene fibers PP with 1 percentage volume ratio were added to the mix. The total length, width, and height of beams were 2100, 200, and 250 millimeter with two 8 mm bars at the top and three 10 mm bars at the bottom with a reinforcement ratio of 0.007, which was almost 31.5% of the maximum reinforcement ratio. Therefore flexural failure rather than brittle failure was expected in all beams. The total stirrup used at the end of beams close to supports was higher than the minimum stirrup required based on design code in order to provide flexural dominated failure rather than shear dominated failure. All five specimens were loaded with four point load system under pure bending at the same method in order to investigate flexural capacity. Load cell, LVDT were applied to measure applied load and increasing deflections, and also different strain gauges were instrumented on steel bars to measure strains during applied load and show the yielding point of steel bars. The details of steel bar reinforcement and also general set-up view of experimental tests were shown in Fig. 1.

* Corresponding Author
E-mail addresses: msharbatdar@semnan.ac.ir (Mohammad Kazem Sharbatdar), m_ahmadpanahi@yahoo.com (Mehdi Ahmadpanahi).



(a)

(b)

Fig. 1. Test details: a) Steel bar arrangement, b) The general test set-up view

3. Results and discussion

Different qualities and quantities results were obtained in this research. The results indicated that HPFRCC layers had a higher effect on ductility than that of flexural capacity and ductility and energy absorption, and other parameters. The maximum increase of yielding and ultimate load capacity of specimens were up to 17 and 31%, respectively, happened at RCHS II specimen with initial grooves and formwork. The cracking load at that specimen was increased up to two times. The maximum increase of ductility of specimens was up to 64 % at the same specimen RCHS II., and also the hardening of this material was observed at the load-displacement curves of strengthened specimens. The maximum experimental to theoretical moment capacity of specimens was 1.14. The increasing ductility of specimens with grooves was more than that of the un-grooved specimen. The test load-displacement curves of some beams are shown in Fig. 2 and all test results are given in Table 1.

Table 1. Test Results

Beam	P_{cr} (kN)	P_y (kN)	P_u (kN)	$\frac{P_{cr}}{P_{cr}(RC)}$	$\frac{P_y}{P_y(RC)}$	$\frac{P_u}{P_u(RC)}$
RC	15	49	70	1.00	1.00	1.00
RCH I	23	55.3	71.33	1.53	1.13	1.02
RCH II	27	57.5	80.7	1.80	1.17	1.15
RCHS II	31	56	91.3	2.07	1.14	1.30
RCHS I	28	48.8	81	1.87	1.00	1.16

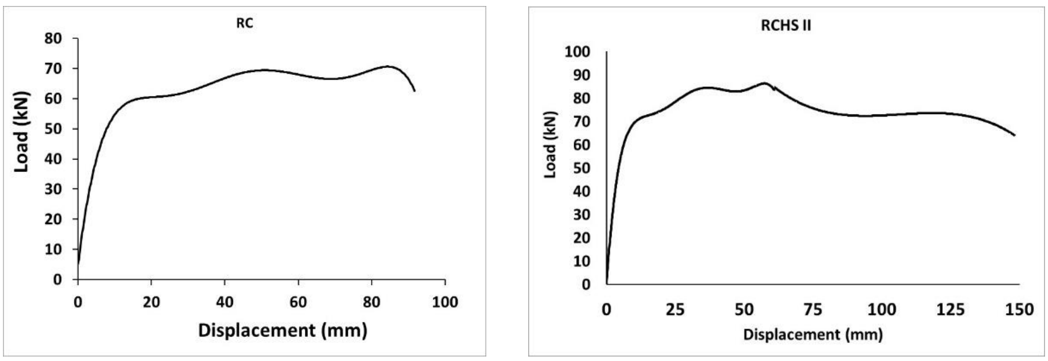


Fig. 2. Load-displacement curves of tested beams

4. Conclusions

The effect of structural performance and different arrangements of new material layers of this advanced material on five strengthened reinforced concrete beams was experimentally investigated in this paper and their results were compared to each others. The test results showed that this proposed method could be used and applicable for strengthening the deficient or damaged reinforced concrete beams.

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