Study on bearing capacity of the reinforced concrete beam with experimental CFRP

Yuanyuan Li[1, 2, a *], Bin Guo[3] and Jiang Liu[1]

[1]Qingdao Technological University, Linyi, China

[2]Shandong University of Science and Technology, Qingdao, China

[3] DaLian Kaiser construction co., LTD. Qingdao branch, Qingdao, China

[a]740185436@qq.com

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Abstract. For research on the strengthening and repairing technology of the concrete flexural members, mechanical properties and deflection deformation of reinforced concrete flexural members are studied by means of several experiments which are pasted the carbon fiber cloth in tension section. This article made the contrast test reinforced concrete beams and the pasted carbon fiber cloth reinforced concrete beams and conducted the static bending load experiment. This research works on the characteristic parameters of the fiber cloth and cross section area of beams had been done, then the suitable technical parameters of reinforce engineering are given. Based on the flexural experimental of reinforced concrete beam with two ways of paste fiber cloth and two the cross-sections beams, pasting fiber cloth in tensile area of reinforced concrete beam can not only improve the bending capacity of flexural member, but also improve the section flexural stiffness and the crack resistance of the components. The results showed that the bearing capacity of pasted fiber cloth reinforced concrete is obviously improved under the condition of same cross section area. Static bending test results show that the existence of fiber cloth can improve the mechanical performance index of component and slow the development of the cracks generated. The bearing capacity and ductility of the CFRP reinforced concrete beams are better than that of ordinary concrete members. Research and analysis show that the use of carbon fiber cloth can effectively reduce the cross-sectional area of the reinforced concrete beam and steel consumption.

Introduction

The carbon fiber cloth reinforcing structure technology is a fast developed technology in recent years in the structure reinforcement in the world[1]. For too large deformation or too crack width in the use of phase produce, can not meet the requirement of the normal use of reinforced concrete beam; Due to the change of the use function, component needs to change its performance and to improve cross section stiffness[2]; The method of flexural bearing capacity of concrete structure with carbon fiber cloth in the tensile area is a feasible way[3]. Pasting carbon fiber cloth on the surface of reinforced concrete members with building structure adhesive, can make fiber cloth and the components to combine into a whole. The flexural bearing capacity is greatly improved compared to that before reinforcement, which is proved by more experimental studies and articles[4-6]. Compared with other strengthening methods, pasting carbon fiber cloth strengthening method has some obvious advantages, such as not increase the load of component and structure, not change the original design of the structural system, the short construction period, not change the component section, etc[7]. Therefore fiber cloth is widely applied to improve the bending and shear capacity of the building structure of reinforcement engineering. The code for design of strengthening concrete structure gives the calculation method of flexural and shear capacity and the corresponding calculation formula of the pasted fiber cloth reinforced concrete. According to the fiber cloth reinforced concrete beams experimental study, this paper analyzed the flexural bearing capacity and deflection of reinforced concrete beam with fiber cloth and put forward suggested calculation method.

Test overview

This test use paste fiber cloth in the tensile area of concrete to improve the flexural capacity and the section stiffness of the beam, and then through the reinforced concrete beam under bending test to study the bending section stiffness and the crack resistance of the reinforced concrete beam.

Component production

The concrete design strength is C30, stirrup for HPB300, longitudinal reinforcement for HRB335 in this experiment. Carbon fiber cloth is provided by the manufacturer in Jiangsu province. Epoxy adhesive is product by the manufacturer in Shandong province. Material properties are shown in table 1，table2.

Table 1 Mix proportion of concrete

Raw material	cement	River sand	Gravel	Water	Sand ratio
1 m^3 material consumption /kg	375	620	1255	175	33%
mix proportion	1	1.65	3.35	0.47	

Table 2 Reinforced material performance

Steel grades	Diameter	Yield strength	Tensile strength	Elongation
HPB300	8	300	420	25.0
HRB335	16	335	455	17.0

In this model test, relatively large rectangular section of the specimen was adopted, specimen size respectively 150 mm × 250 mm ×250 mm and 150 mm × 300 mm× 2500 mm. Specimen contains four groups，the first group to contrast specimen B1 (150 mm×250 mm ×250 mm)，the second group to paste fiber cloth in the bottom of beam B2 (150 mm×250 mm ×250 mm), the third group to paste fiber cloth in the bottom and side of beam B3(150 mm×250 mm ×250 mm), the fourth group to enlarge section specimens (150 mm×300 mm ×300 mm). Grinding rounded corners about 30 mm at the corner of concrete beam to prevent carbon fiber cloth fracture caused rupture stress concentration. The strain gages are placed in each beam to test the longitudinal main reinforcement strain. The section size, number and reinforcement methods of concrete beam are shown in table 3.

Table3 The size parameters of beams

Specimen	Specimens characteristics	Width（mm）	Height（mm）	Reinforcement	Reinforcement ratio（%）
B1	Contrast beam	150	250	2Φ16	2.1
B2	Bottom paste fiber cloth	150	250	2Φ16	2.1
B3	Bottom and side paste fiber cloth	150	250	2Φ16	2.1
B4	Enlarging the cross section	150	300	2Φ16	1.8

Experiment method

By using two concentrated loading method, the load was applied on the top of the test beam by assigning beam. Grading loading, loading 15 kN per grade. In the process of loading, observe the crack, testing the main reinforcement strain value and mid-span deflection. The failure load and failure modes of the all specimens are shown in table 4, all components are flexural failure.

Table4. The bending capacity limit and failure modes of specimens

Specimen	Specimens characteristics	Failure load	Failure mode
B1	Contrast beam	58.6	bending failure
B2	Bottom paste fiber cloth	63.1	bending failure
B3	Bottom and side paste fiber cloth	72.7	bending failure
B4	Enlarging the cross section	70.2	bending failure

Experimental analysis and theoretical comparison

Concrete cracks

The crack development of pasted fiber cloth reinforced concrete specimens is basically the same that of ordinary reinforced concrete specimens. The destruction form of the four groups reinforced concrete beam is bending failure. The fracture spacing of pasted fiber cloth reinforced concrete beam (B2, B3) is smaller than that ordinary specimen at failure, accordingly the crack width is smaller than it when using load. In the ordinary reinforced concrete beam, crack spacing of B4 beam is bigger than B1. Crack width of B3 beam is smaller than that of B2 beam in the pasted fiber cloth reinforced concrete beam

Bearing capacity

In this experiment the bearing capacity of all the reinforced beams is improved to varying degrees compared that of contrast beam. The test results of the bearing capacity of beam are shown in table 4.

Load-deflection curve

Due to the fiber cloth was pasted the surface of the concrete in the tension zone, equivalent to increase the amount of reinforcement, flexural rigidity of component section increase accordingly. Because the distance between fiber cloth and the compressive concrete zone of beam is greater than that of the steel bar, so the bearing capacity of the fiber cloth is bigger than that of the same cross-sectional area of reinforcing steel bar.

As shown in figure 1 for the measured load deflection curve of reinforced concrete beam B1, B2, B3 and B4 specimen. Therefore the fiber cloth can improve the flexural rigidity of component section. Because of the pasted fiber cloth at the bottom of reinforced concrete beam, reinforcement effect is better. The fiber cloth at bottom of beam, no matter the posted fiber cloth at side of beam or not, the flexural rigidity of beam section is improved markedly after reinforcement. The load deflection curves of the B2, B3 specimens have an obvious turning point, the deflection is smaller than that of before strengthening. The load deflection curves of the B2, B3 specimens, from the figure comparison to before and after pasted fiber cloth, section stiffness increased obviously since the starting point.

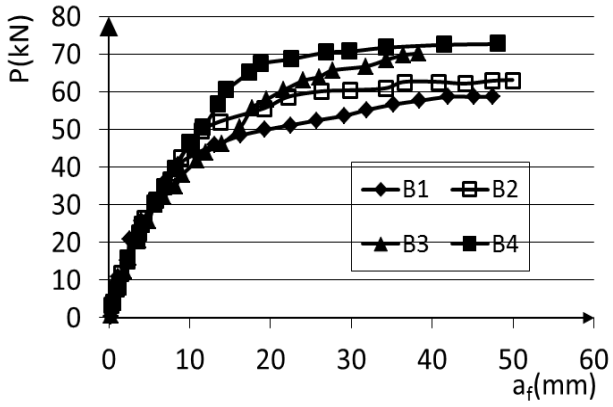

Fig.1 Load-deflection curve

Conclusion

(1) Pasting carbon fiber cloth reinforced concrete structure in the tension zone can improve the flexural capacity of the component and improve its mechanical performance index.

(2) Pasting carbon fiber cloth at the surface of concrete can effectively inhibit the fracture development .

(3) The pasted fiber cloth on the side of the beam can obviously increase the flexural bearing capacity and achieve the bearing capacity of expanded beam. In other words the use of fiber cloth can effectively reduce the cross-sectional area of the reinforced concrete beam. The fiber reinforcement technology are applicable for both new structure and existing building, has a certain guiding significance in actual project.

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