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Shear Reinforcement of RC Beams Using Carbon Fiber Sheets

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Summary

An experimental study was conducted on shear reinforcement of reinforced concrete beam using carbon fiber sheets. The results indicated that ultimate shear strength of the strengthened beam is about 1.3 to 1.8 times higher than that of the virgin beam and similar shear-reinforcing effects of the sheets are obtained for the crack-damaged and afterwards repaired beam.

Introduction

External epoxy-bonding of thin carbon fiber reinforced plastics sheets (hereafter called the CF sheet) is a superior technique for strengthening of existing reinforced concrete (RC) structures or repair of deteriorated RC ones since the CF sheet is light in weight, high in stiffness and strength and superior in durability, and also the bonding work is easy and not skilled. Authors have already performed experimental studies on flexural and shear reinforcement of RC beams using the CF sheets and presented the results that ultimate flexural strength of the strengthened beam is increased by about two times that of the virgin one and any shear cracks can not be observed in the shear-strengthened area of the beam (1,2). This paper presents the results of a further experimental study on shear reinforcement of RC beams using the CF sheets.

Experimental

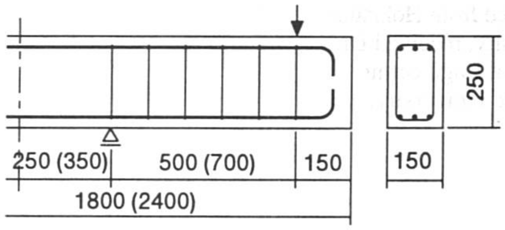
The configuration and bar arrangement of the RC beam specimen is shown in Fig.1. The specimens had a same cross section and two different lengths and shear spans. The stirrups were not arranged in the central shear span. Some specimens were initially crack-damaged by pre-loading and subsequently repaired by injecting epoxy resin into the cracked parts. The arrangement of the CF sheet is shown in Fig.2. Double sheets were bonded crosswise each other over both sides of the beam by epoxy resin adhesive. One more sheet was intentionally arranged on the soffit of the beam to reinforce the tension side of the beam. The bonding work was performed according to the same procedures as presented in Ref.1 and 2. The test was conducted under antisymmetric loading system as shown in Fig.2.

Results, Discussion and Conclusions

Photos 1 shows failure mode of the strengthened beam after the test. The bonded sheets were peeled off by force. All of the specimens failed due to diagonal tension cracking in the central shear area. Table 1 shows the measured values of cracking load P_{cr} and ultimate load P_u of the beam with the central shear span L=250mm. The cracking load P_{cr} was estimated from shear deformation behaviors measured in the central shear span. Specimen A was initially crack-damaged nearby ultimate stage by pre-loading, and subsequently repaired and strengthened. Specimen B was lightly crack-damaged, and strengthened. The results obtained are as follows. The reinforcing effect of the sheet was small for crack initiation. The ultimate shear strength of the strengthened beam increased by about 1.4 times that of the virgin one. The increasing rate of strength was about 1.3 to 1.8 for the beam with L=350mm. Similar reinforcing effects of the sheet were obtained for the crack-damaged beam and the crack-damaged and afterwards repaired beam.

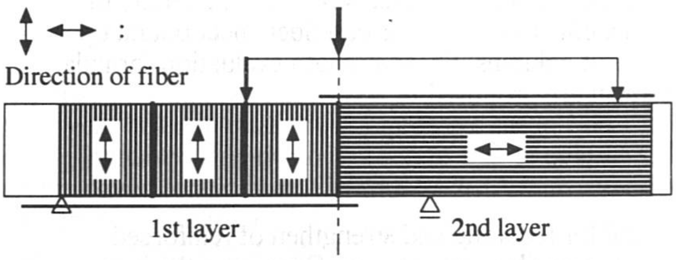
References

1. K.Takeda et al.: Composites Part A 27A(1996) 981-987.
2. Y.Mitsui et al.: Textile Composites in Building Construction 96, 91-98.



Main reinforcement : upper ; 3-D10 (SD345)
lower ; 3-D10 (SD345)
Stirrup : ϕ 5, @100mm
Concrete : nominal strength = 21MPa

Fig.1 Configuration and bar arrangement of specimen



Carbon fiber sheet (CF sheet) :
T. S. = 3400 MPa, T. M. = 2.3 x 10^5 MPa
Section area of CF = 167 mm^2/m
Adhesive agent : epoxy resin
Crack repairing material : epoxy resin

Fig.2 Arrangement of CF sheets and loading method (antisymmetric load)

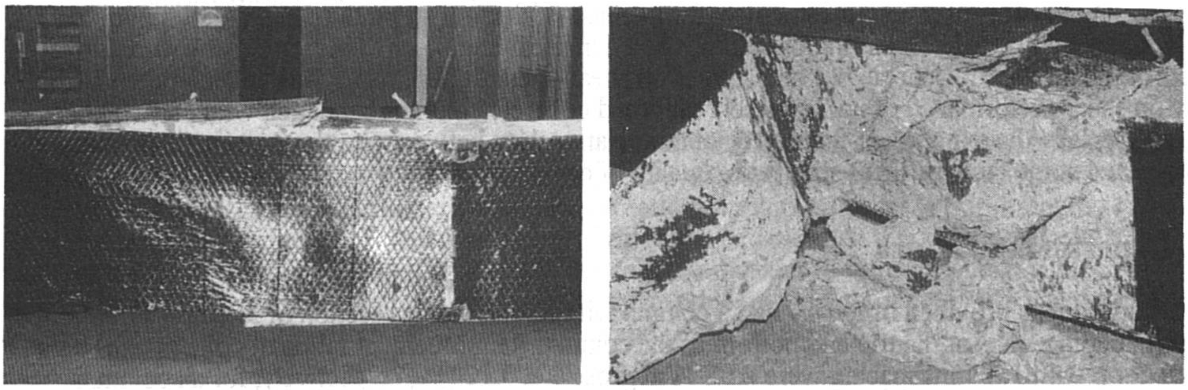


Photo 1 Failure mode of the strengthened beam after the test

Table 1 Test results (central shear span L = 250mm)

Specimen No.	State of Specimen	Pcr (kN)	Pu (kN)
A	virgin	125.5	188.3
	repaired and strengthened	58.8	268.7
B	virgin	103.0	-
	strengthened	73.5	274.6
C	strengthened	132.4	256.9

Pcr : cracking load
Pu : ultimate load