REPAIR OF REINFORCED CONCRETE BEAMS WITH ADHESIVE BONDED STEEL PLATES

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ABSTRACT

An investigation of the behaviour of reinforced concrete beams repaired with steel plates at its soffit is presented in this paper. Reinforced concrete beams were pre-loaded to 85 % of their ultimate capacity and subsequently repaired by bonding steel plates of different widths. Different widths of steel plates were used in order to determine the width-to-thickness ratio that will promote ductile behaviour. It is shown that strengthening of significantly cracked beams by bonding steel plates is possible and beams can be restored to stiffness and strength values superior to those of the original unplated beams.

Keywords: Flexural strength, steel plates, concrete beams, repairing, epoxy

INTRODUCTION

External steel plating is a common repairing technique in reinforced concrete (RC) beams. The technique does not require skilled labour and the external plate contributes to the ductility of the beams [1]. Epoxy glues are convenient products for bonding steel to concrete. They show an excellent bond between the steel and concrete, and their shrinkage at hardening is practically zero [2].

EXPERIMENTAL PROGRAMME

Coupon tests were prepared to establish the yield stress (f_y), ultimate stress (f_u) and the elastic modulus (E) of the 6mm thick steel plates, 12mm, 10mm and 8mm reinforcing steel bars. The corresponding average properties of the steel plates and the reinforcing steel bars are 302.27, 552.89, 559.95 and 366.01MPa, respectively. Concrete cubes of dimensions 100x100x100 mm were cast, and cubes were tested to give an average compressive strength of 33.22 MPa.

A total of 6 reinforced concrete beams (200 mm wide by 350 mm deep by 3000 mm length) were cast and two beams were used as control beams. The beams were reinforced with 2, 10 mm high yield ribbed bars in the compression zone, 2, 12 mm

high yield ribbed bars in the tension zone, and 8 mm diameter mild stirrups, spaced at 250 mm centre to centre, were provided to resist shear. Four beams were preloaded to 85% of the ultimate load of the control beams. After cracking the beams, they were then repaired by bonding steel plates of different widths on the tension face of the beam, using epoxy adhesives. In order to ensure proper adhesion between the concrete and steel, the damaged beams were scabbled in order to expose the aggregates, and steel plates were sandblasted in order to remove the oxide layer and roughen the surface. Both, the control and repaired beams were tested, under two point loading, until failure.

BEAM RESULTS

The strength results for control beams (CB-1 and CB-2) and repaired beams (RB-75-1, RB-125-2, RB-175-3 and RB-200-4) are shown in Table 1. As shown in this table, the ultimate loads of the pre-loaded beams increased by large margin when they were repaired with steel plates. This was accompanied by a significant reduction in deflection. Although there was a huge increase in the ultimate loads, the beams did not reach the code flexural yield strengths, as predicted by SANS 10100-1 [3]. The composite beam failed prematurely either a combination of flexure and shear, peeling of the plate and concrete cover or delamination of the plate.

Table 2: Summary of repaired beam results

Beams	Specimen	Load (kN)	Test Moment (kNm)	Pred. moment (kNm)	Deflection (mm)	Crack width (mm)
Control beams	CB-1	75.08	35.02	35.63	62.10	10
	CB-2	71.33	33.28	35.63	30.2	8
	Average	**73.2**	**34.15**	**35.63**	**46.15**	**9**
Repaired beams	RB-75-1	162.94	72.63	83.04	8.90	4
	RB-125-2	189.37	84.71	112.54	9.98	4
	RB-175-3	146.99	62.50	137.45	7.98	3.5
	RB-200-4	161.32	74.50	148.17	7.83	2
	Average	**165.15**	**73.59**	**120.3**	**8.67**	**3.4**

CONCLUSION

This experimental investigation has demonstrated that the flexural performance of pre-cracked beams can be increased to a level that is higher than the control beams, by bonding steel plates to their soffits, using epoxy adhesives. The increase in strength was accompanied by a substantial decrease in deflections. However, the effectiveness of this technique depended on the surface preparation and bonding methods between the existing beam and the steel plate.

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