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Compression Zone Rehabilitation of Damaged RC Beams Using Poleyster Glue Line

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Abstract: The effect of crashing damage on the performance of RC beams repaired with polyester glue line was investigated and presented in this study. Seven reinforced concrete beams (12×18×122 cm) were tested under two points loading condition until failure. Two parameters were studied experimentally. Prior to rehabilitation 3 cm of compression zone (0.2 D) of the beams was removed to different levels of damaging (10, 20 and 30% of tested length). The rehabilitation with polyester glue line was accomplished in two approaches. First one only the polyester glue line was applied on damaged zone of RC beams while shear connecters were used in the second approach. The data indicated that pre-damaged rehabilitation RC beams exhibited ultimate capacities about 24.1% average higher than that of undamaged beam. Also, the results showed that the increase of the load capacity when the shear connecters were used was slightly as compared with the case of rehabilitation without shear connecters. The study shows that polyester glue line was able to recovery flexural strength of damaged beams.

Key words: RC beams, polyester glue line, rehabilitation, flexural, experimental, connecters

INTRODUCTION

The rehabilitation sector has achieved a greater significance than the construction of new buildings in recent years due to the calamity in the construction of buildings. Experimental researches with using appropriate rehabilitation techniques have been carried out in recent years to strengthen RC beams. Chalioris and Pourzitidis (2012) studied the rehabilitation of shear-damaged RC beams using self-compacting concrete jacketing by constructing 5 RC beams and loading in order to exhibit shear failure. The damaged beams were restored using comparatively thin reinforced jackets and retested by the same loading. The capacity of the jacketed beams was fully restored or ameliorated with respect to the initially tested specimens.

Al-Zaid *et al*. (2014) investigated the structural behavior of damaged wide shallow RC beams strengthening with CFRP plates by testing eight fully scale beams under four points load. The structural damaged was obtained by pre-cracking the beams under two loading levels (35-95%). All strengthened beams showed improved flexural performance as compared with control beam.

Vercher *et al*. (2017) discussed theoretically the flexural strengthening of damaged T-joists with severe corrosion using CFRP sheets. The research is conducted for the cases of T-joist with complete corrosion of the lower reinforcement and repaired T-joists with a several number of CFRP sheets. The results showed that the simply supported T-joists beams with severe corrosion do not close the load factor or ACI 318 requirements, even with a large number of CFRP sheets. On the other hand, fixed-ended cases can be kept in use despite corrosion by applying light CFRP strengthening and with 4 sheets the initial safety is restored.

By noticing the recent researches, it can be observed that the rehabilitation of damaged compression zone was not investigated and repair or strengthening was executed with expensive materials. In this study, the crushed compression zone will be repaired with polyester glue line (very easy to use, high performance and low cost).

MATERIALS AND METHODS

Experimental program: A series of seven reinforced concrete beams were designed according to ACI 318 M and casted using normal strength concrete and tested to study the effectiveness of polyester glue line performance on damaged beams. All details of specimens are illustrated in Table 1 and Fig. 1 (according to ASTM C 702-98) (Anonymous, 2011). Experimental variables included length of damaged region and using the shear connecters to prevent debonding. Mixture information are listed in Table 2. The compressive strength obtained by testing three standard cylinders (100×200 mm) at 28 days age was 29.4 MPa.

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Table 1: Characteristics of beams

Beam details	Beam name
Control beam	R
10 cm damaged	R 10
20 cm damaged	R 20
30 cm damaged	R 30
10 cm damaged with one shear connecter	B 10
20 cm damaged with two shear connecters	B 20
30 cm damaged with four shear connecters	B 30

Table 2: Concrete mix design

Parameters	Amount
Water/cement ratio	0.5
Water (kg/m^3)	230.0
Cement (kg/m^3)	460.0
Fine aggregate (kg/m^3)	680.0
Coarse aggregate (kg/m^3)	1120. 0

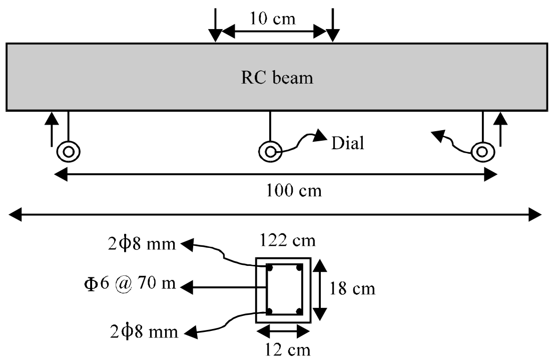

Fig. 1: Test specimen

Materials: Each component of concrete were tested according to the compatible specification. Portland cement and aggregate were conformed to ASTM C143/C143M-00 and ASTM C33-02, respectively (Anonymous, 2014). Three samples for each steel bars diameter that used for reinforcement (6 and 8 mm) were tested to determine yield strength (A615/A615M-01b) (Anonymous, 2003). The average of yield stresses were 456 and 486 MPa for ϕ6 and 8 mm, respectively.

Polyester glue line: The properties of polyester glue line is straw solid cream polyester resin processed with suspended minerals as shown in Fig. 2. It is especially recommended for gluing, repairing or making stuccowork. The characteristics are strong binding power, rapid hardening, easy application, very good polish and homogeneous color. The physical properties obtained from manufacturing data (http://www.b-chem.net/) are listed in Table 3.

Instrumentation and test setup: After curing and rehabilitation mechanical testing of the beams was carried out (ASTM C192/C192M-02) (Anonymous, 2001, 2002a-c). Vertical deflections were measured near the

Table 3: Polyester glue line manufacturing specifications

Property	Tensile stress	Flexural elastic modulus	Maximum flexural stress
Method	ASTM D 638	ASTM D 790	ASTM D 790
Result	9.6±0.6 MPa	4830±785 MPa	27±4 MPa

Fig. 2: Polyester glue line

Fig. 3: Testing machine of RC beams

supports and at midspan using three dial gauges so that the net displacement can be obtained by deducted midspan displacement from the average of displacements close to supports as shown in Fig. 3.

Strengthening of damaged specimen: After crashed intended region of beams (3 cm from depth) of compression zone with different length (10, 20 and 30% of tested length of specimen at center), result crushed surface was cleaned by potable water and was left it until dray as shown in Fig. 4a. The ϕ10 mm holes for shear connecters was drilled along the center line of beam with depth of 5 cm at 7 cm center to center spacing. The shear connecters were fixed to the holes using the same polyester glue line shown in Fig. 4d. The polyester resins were prepared following the manufacturer's directions by mixing two components (resin and hardener components). The hardener was add with 2% of the polyester glue line and mixed using low speed drill. The mixed resin was applied on damaged zone using a trowel as shown in Fig. 4g.

Fig. 4: Repairing with polyester glue line: a) Clean the damaged zone; b) Hole of shear connecter; c) Shear connecter; d) Fixed shear connecter; e) Mixing polyester glue line; f) Pervading polyester glue line; g) Adjustment polyester glue line and h) Repaired damaged zone

RESULTS AND DISCUSSION

The benefit of the present rehabilitation method is shown in load displacement curves from Fig. 5-13 and the test results are tabulated in Table 4. The test results will be discussed for the two cases of rehabilitation (with shear connecters and without shear connecters) in terms of first crack load, ultimate load, ductility and failure modes.

Beams without shear connecters: Three beams were tested to study the effect of using polyester glue line. The results of these tests are shown in Fig. 5-9 referred to noticeably increase in the first crack load, ultimate load and ductility.

Beams with shear connecters: Three beams were tested to study the effect of addition shear connecters to the polyester glue line on flexural behavior. This addition

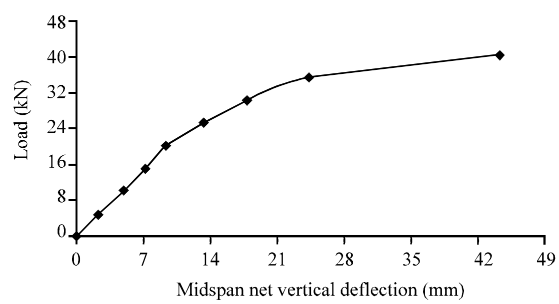

Fig. 5: Load-midspan displacement of specimen R

Table 4: Results of the test specimens

Sample codes	First cracking load (kN)	Ultimate load (kN)	Failure mode
R	7	43.2	Nominalgradual
R10	10	51.5	Gradual
R20	10	52.4	Gradual
R30	10	53.3	Gradual
B10	10	52.8	Gradual
B20	10	54.5	Gradual
B30	10	57.2	Gradual

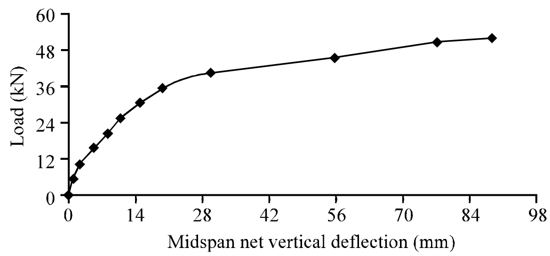

Fig. 6: Load-midspan net vertical deflection of specimen R10

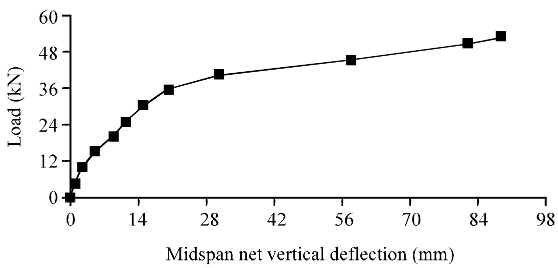

Fig. 7: Load-midspan net vertical deflection of specimen R20

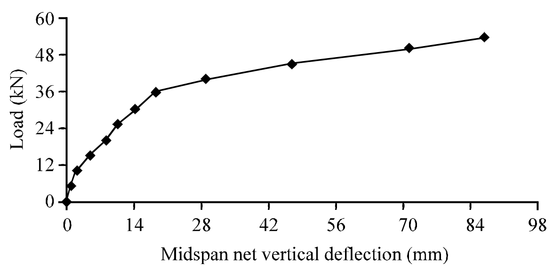

Fig. 8: Load-midspan net vertical deflection of specimen R30

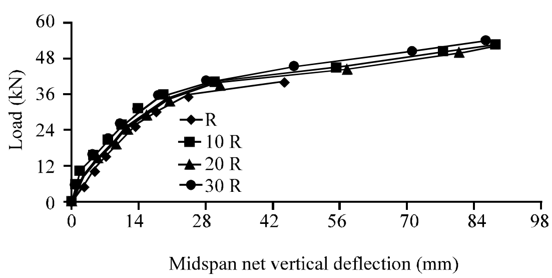

Fig. 9: Load-midspan net vertical deflection specimens R, R10-30

afford slight enhance in the ultimate load and ductility from that obtained of beams without shear connecters while the first crack load was equal as shown in Fig. 9-14.

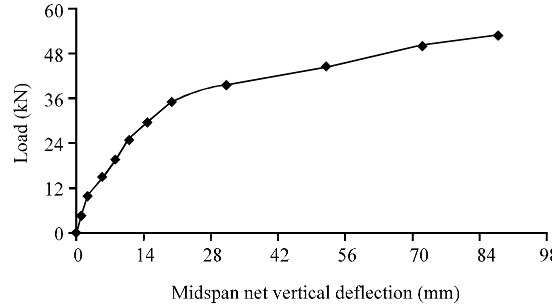

Fig. 10: Load-midspan net vertical deflection of specimen B10

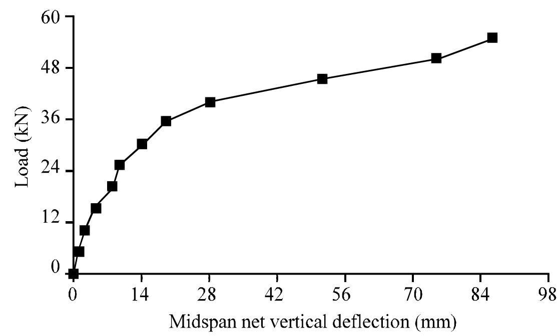

Fig. 11: Load midspan net vertical deflection of specimen B20

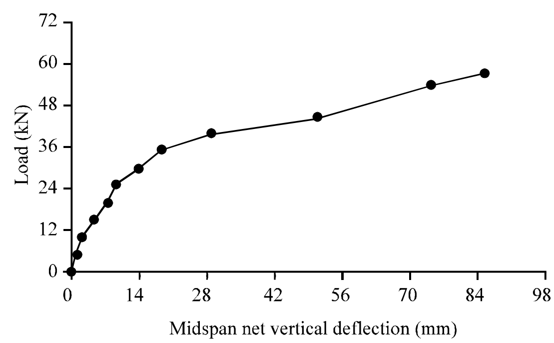

Fig. 12: Load-midspan net vertical deflection of specimen B30

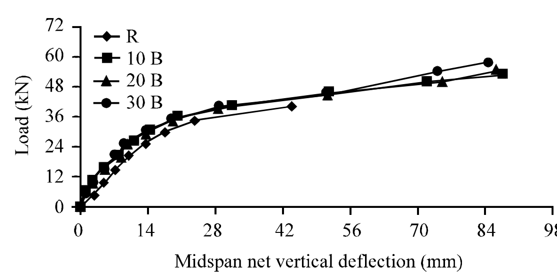

Fig. 13: Load-midspan net vertical deflection of specimens R, B10-B 30

Fig. 14: Beams after failure: a) R30; b) B30; c) R20; d) B20; e) R10; f) B10 and g R

CONCLUSION

Based on experimental results following conclusions are noticed. One can see that first cracking load increased by 42.8% when the damaged beams are repaired with polyester glue line for all rehabilitation patterns. Using polyester glue line without shear connecters improved ultimate load capacity by 19.2, 21.3 and 23.4% for beams R10, R20 and R30, respectively. While beam with shear connecters 22.2, 26.2 and 32.4% for beams B10, B20 and B30, respectively. The ductility is increased in rehabilitated beams comparing with undamaged beams.

The failure of all rehabilitated beams occur when the concrete was crushed at the end of polyester glue line as shown. Also, polyester glue line still bonded with concrete after failure for all specimens. Significant enhancing of beams behavior when the polyester glue line was used as compared with other strengthening materials, especially in cost.

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