Three Tests on Epoxy-Repaired Reinforced Concrete Beams

By **Dr. H. W. Chung***

The purpose of these tests was to investigate the efficiency of Adhesive Engineering's proprietary method of epoxy injection for the structural repair of reinforced concrete beams.

Test Specimens

Three reinforced concrete beams, 5 in. by 8 in. in cross-section and 9 ft. 6 in. long, were fabricated. The tensile reinforcement in each beam consisted of two 1/2-in. diameter high tensile steel bars. The yield stress of the steel was 68,000 lb/in^2. The shear reinforcement consisted of single stirrups of ¼-in. diameter high tensile steel wires spaced at 6-in. center to center throughout the span of the beam. Details of the test specimens are shown in Fig. 1. The concrete mix was 1:2:4 by weight and the cylinder strength was 2700 lb/in.^{2}.

Testing Procedure

The beam under test was simply supported over a span of 9 ft. Two equal point loads were applied to the third-points of the beam by a pair of hydraulic jacks. Mid-span deflection of the beam was measured with a dial gauge. Loading was increased by small increments until the beam failed. After each increment of loading, the deflection was recorded and the propagation of cracks was examined.

The damaged beam was then repaired by injecting the cracks full depth with a low viscosity, fast-curing, slump-pumping liquid epoxy adhesive. Injection repairs were performed by Inter Pacific Ltd., an experienced crack injection contractor headquartered in Hong Kong.

The perimeter of each cracked section was sealed off with either a rapid-setting epoxy adhesive or a temporary seal, leaving several small holes for the subsequent injection and relief of the structural adhesive. When the surface seals had cured, the epoxy adhesive was injected into the cracks.

Only the major cracks were treated in this way. The minor cracks, being less than 0.002 in., were too fine for complete penetration of the structural epoxy. The crushed concrete in the compression zone of the beam was repaired in a similar manner. The repaired beam was left at ambient temperature for four days and then tested to failure as before.

Test Results

Failure of the original beams was caused by yielding of the tensile steel, followed by concrete crushing in the compression zone. The mid-span deflection measured before failure was over 1 in., and the residual deflection after release of load was about 0.5 in. The constant moment region was traversed by several wide cracks, the maximum crack width being 0.03 in.

The behavior of the repaired beams was similar to that of the original beams. Under loading, the repaired cracks did not reopen. Instead, new cracks were formed, some being adjacent to the old ones. At failure, concrete crushing occurred away from the epoxy-repaired region.

Test results are summarized in Table 1. It is obvious that the strength of the repaired beams was not lower than those of the original beams. Also, the deformation capacities of the repaired beams and the original beams, as evidenced by their maximum deflections, were of the same order of magnitude.

that permanent deflection (which could not be eliminated by the repair process), existed in the repaired beam before any load was applied.

Comparison of the load-deflection curves indicates that the integrity of the beams was restored by epoxy injection. The repaired beams exhibited greater flexural rigidity at high intensities of load. Nevertheless, there was no significant loss in ductility, for the repaired beams could deflect to the same extent as the original beams.

Conclusion

The limited test results reported herein have led to the following conclusions concerning the efficiency of epoxy injection for structural repair of reinforced concrete beams:

1. The repair process restores the integrity of the beam.
2. The flexural strength of the repaired beam is not less than that of the original beam.
3. The repaired beam may be slightly stiffer than the original beam, but the loss of ductility is not significant.
4. The repaired cracks do not reopen even at failure of the beam.

Table 1: Summary of Test Results

	Beam 1		Beam 2		Beam 3	
	Original	Repaired	Original	Repaired	Original	Repaired
Cracking load(lb)	1,400	1,500	1,300	1,300	1,300	1,600
Ultimate load(lb)	10,000	10,600	9,600	10,000	9,700	9,900
Max. deflection(in)	1.27	1.26	1.27	1.48	1.10	1.03
No. of cracks repaired	—	10	—	13	—	6

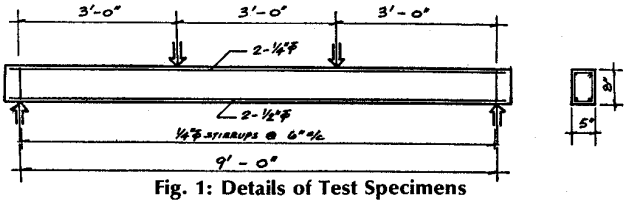

Fig. 1: Details of Test Specimens

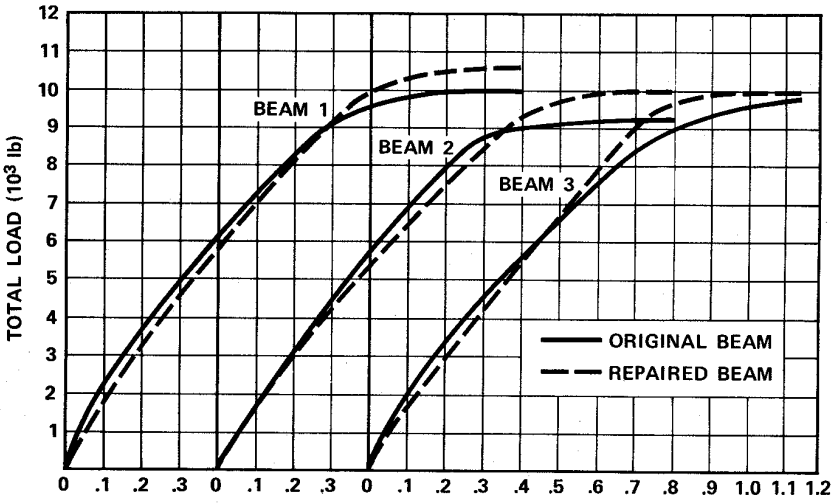

Fig. 2: Load-Deflection Curves — Mid-Span Deflection (in.)

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