

Rehabilitation of RC Beam by Using Synthetic Resins

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ABSTRACT: This study investigates the use of three different types of Synthetic resins and adhesive materials like epoxy bonding agents, super latex and gfrp wrapping for repairing the reinforced concrete beams. In this research, 6 standard size beams(75X150X1750mm) for M20 grade of concrete were distress in flexure by applying two points load by taking 90% of the ultimate load. Then, these distressed beams were repaired and retested up to ultimate failure load. The aim of this study is to determine the suitability of synthetic resin material type to be used in RCC beams for repairing and restoring good strength and for considering economical aspects. Hardened concrete specimens were tested for compression, and flexural test. The results of these experiments show that the beams repaired using epoxy bonding agent gave higher Increase in the ultimate load than other synthetic Resins. The flexural strength increased significantly up to about 15 percent for concrete beams repaired with epoxy bonding agent compared to other synthetic resins and adhesive materials. Deflections were smaller in reinforced concrete beams with epoxy bonding agent compared to conventional concrete beams. Compare to all the three types of synthetic resin and adhesive materials used i.e. epoxy bonding agent is more economic than other two materials. Though reinforced concrete beams repaired with epoxy bonding agent is costlier comparatively, it is cheaper than to reconstruct the structure.

KEYWORDS: Epoxy bonding agent; distress; flexural strength; Repairs and Rehabilitation.

I. INTRODUCTION

Structural rehabilitation represents an important aspect of the construction industry and its significance is increasing. Several methods are available, each with different advantages and handicaps. However, little information is available and insufficient code guidelines are accessible. In fact, most repair and strengthening designs are based on the assessment of engineers only and often, empirical knowledge and current practice have an important role in the decisions to be made. The purpose of repair is to improve the function and performance of the structure, restore and increase the strength and stiffness, improve appearance of the concrete surface, provide water tightness, prevent access of corrosive materials to the reinforcement, and improve the durability performance of the structure. Rehabilitation and strengthening of old structures using advanced materials is a contemporary research in the field of Structural Engineering. During past two decades, much research has been carried out on shear and flexural strengthening of reinforced concrete beams using different types of fiber reinforced polymers and adhesives. Strengthening of old structures is necessary to obtain an expected life span.

Life span of RC structures may be reduced due to many reasons, such as deterioration of concrete and development of surface cracks due to ingress of chemical agents, improper design and unexpected external lateral loads such as wind or seismic forces acting on a structure, which are also the reasons for failure of structural members. The superior properties of polymer composite materials like high corrosion resistance, high strength, high stiffness, excellent fatigue performance and good resistance to chemical attack etc., has motivated the researchers and practicing engineers to use the polymer composites in the field of rehabilitation of structures. This paper reviews fourteen articles on rehabilitation of reinforced concrete RC beams. The paper reviews the different properties of Glass Fiber Reinforced Polymer

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

(GFRP), super latex and epoxy bonding agent’s composites and adhesives, influence of dimensions of beams and loading rate causing failure. The paper proposes an enhanced retrofitting technique for flexural members and to develop a new mathematical model.

II. EXPERIMENTAL PROGRAMME

2.1 Materials properties

The concrete mix used for all the beams is designed for a M20 with a water cement ratio of 0.45. Main reinforcing bars of Fe 415 of dia. 8 mm at top and 10 mm at bottom are used. Rectangular closed stirrups of 6 mm mild steel bars.

2.2 Testing Program

Table 1: Details of specimens and materials

Grade of concrete	Designation of beam	Type of adhesive materials used
M20	Set A beams	Epoxy bonding agent
	Set B beams	Super latex
	Set C beams	GFRP

The beams were designated as set ‘A’ beams, set ‘B’ beams, and set ‘C’ beams respectively. So that each two beams have been repaired with different type of adhesive materials and compared their strength. Moulds were removed after 24 hours and the specimens were placed for curing. Three dial gauges were fixed at bottom in order to record the strains. Three gauges were fixed below the beam at middle third and mid span to observe the deflections. The beams were tested in a Universal Testing Machine under two point loading at middle third points of the span.

The whole set up was placed with Universal Testing Machine of 200 ton capacity and subjected to two points loading.

2.3 Experimental set up

The load is applied in small increments and the dial gage readings are taken every 4kN until failure occurs. The deflections are recorded at each level of loading. Cracks are detected and their widths are recorded at several levels of loading. **Figure (2)** shows the loading arrangement used throughout the tests.

Where,

Adopt $a_v/d = 4$

a_v = shear span



Fig.1 loading arrangement of beam

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Table .2 Costs of Adhesive Materials

S.No	Type Of Synthetic Resin	Cost Of The Material Per Liter
1.	Epoxy Bonding Agent	Rs 650
2.	Super Latex	Rs 565
3.	GFRP	Rs 470

III. REPAIR OF CRACKS IN CONCRETE STRUCTURES

Cracks need to be repaired if they reduce the strength, stiffness, or durability of the Structure to an unacceptable level, or if the function of the structure is seriously impaired.

3.1 Repair Procedure by applying of Epoxy Bonding Agent

- The surface for application must cleaned and made free from dirt, grease oil and loose particles before application of epoxy bonding agent, thoroughly removed by any mechanical means
- The hardener part should be poured totally in the base with ratio 0.5.
- The two parts must be thoroughly mixed with a low speed mixer (150 to 200 rpm for about 3 to 4 minutes) to get uniform color of the mixed material. Mixed material should be brushed applied on the prepared surface.
- Overlay of concrete/mortar has to be placed epoxy bonding agent when it is talky. If epoxy bonding agent has dried, apply a 2nd coat before placing of concrete/mortar. After 24 hours RC beams ready to test as two point load condition.



Fig. 2 During Repairing Of Beams By Using Epoxy Bonding Agent

3.2 Repair Procedure by applying of Super Latex

- The surface for application must cleaned and made free from dirt, grease oil and loose particles before application of super latex, thoroughly removed by any mechanical means.
- Adopt plaster ratio 1:4 for cement and sand, and adopt 250ml water + 100ml super latex mix with cement.
- After super latex mixing with cement sealing the cracks in the beams
- And then put it for curing as wet gunny bag, after 24 hours of Curing, beam is retested.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016



Fig. 3 after applying of super latex with beams

3.3 Repair Procedure by Applying Of GFRP

- The surface for application must be cleaned and made free from dirt, grease oil and loose particles before application of epoxy bonding agent, thoroughly removed by any mechanical means
- Firstly albumin 15ml mix with 1 litre resin and then catalyst 16ml mix with those mixtures.
- Sealing the crack by using those mixtures after 1 hour give one coating to that beam.
- After that wrapping the beam by using glass fiber mat.



Fig.4 Coating of beam by using GFRP

IV. TEST RESULTS AND DISCUSSIONS

Behaviour of Original Beams

Generally, in the original beam, the first shear crack started at one shear span at the beam bottom, near the support, and it propagated towards the nearest loading point as an inclined crack (diagonal crack). Some fine flexural cracks were observed before and at the appearance of the first diagonal crack. In some beams (such as set A), after increasing the applied load, another diagonal crack was developed at the other shear span of the beam. With more applied load, the first (major) diagonal crack rapidly propagated to the nearest loading point, and then collapse happened by splitting the beam along this crack.

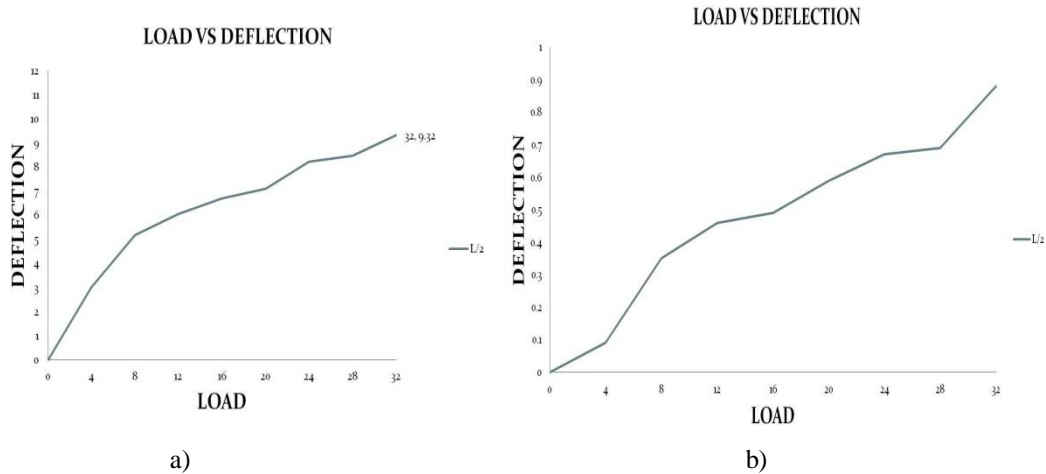


Fig .5. a) Load Vs Deflection for Set A Beam before rehabilitation b) load vs deflection set A after rehabilitation by using super latex

RETESTING AFTER BEAM’S REPAIR

After the repair process is completed, the repaired beams are retested to evaluate the efficiency of the repair work. Loading arrangement and test procedures of the repaired beams are the same as those described for the original beams

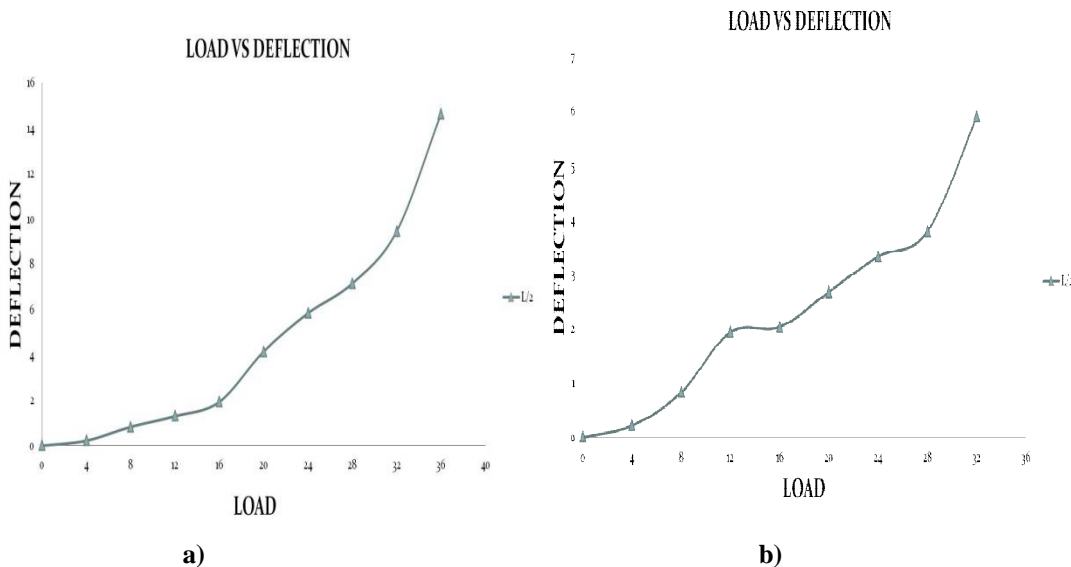


Fig 6 a) Load vs deflection of original beam for set B b) load vs deflection after rehabilitation of set B by using epoxy bonding agent

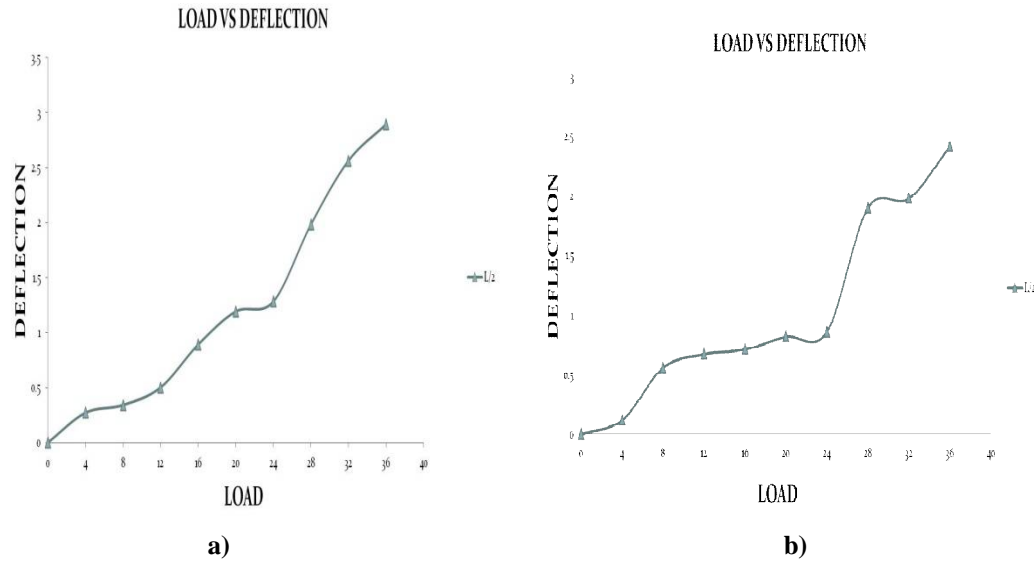


Fig 7 a) load vs deflection before rehabilitation of set C beam b) load vs deflection after rehabilitation of set C beams by using GFRP

The following graph shows the comparison of rehabilitated strength of beams with various materials used.

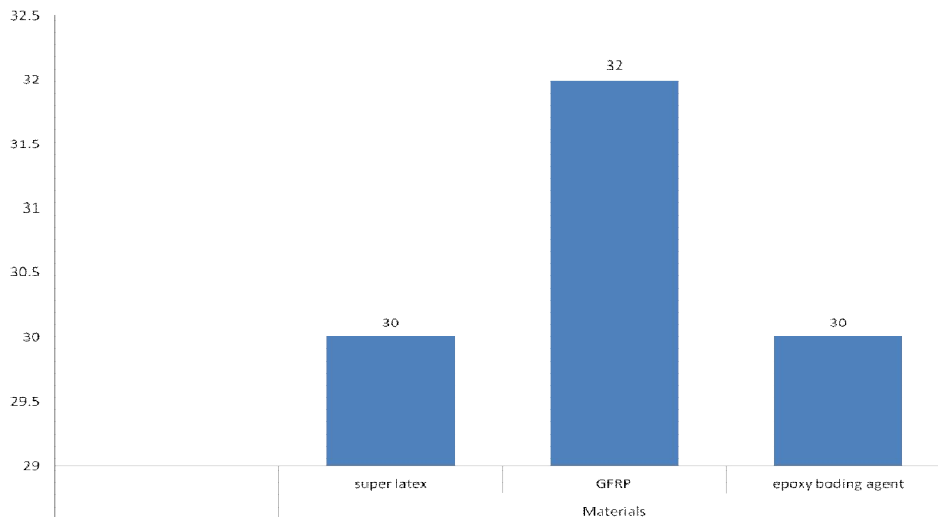


Fig.8 Strength of rehabilitates material based on ultimate load

- From the result GFRP gives better strength among the other resins.
- But GFRP mat and concrete bond does not withstand on the water body passages
- Beams with GFRP wrapping displays de-bonding of GFRP layer leading to their tearing along the diagonal cracks.
- Comparison of Super Latex and epoxy bonding agent, epoxy bonding agent is better, because super latex reduces the aesthetical sense of beams and crack reappears on the repaired area.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

V. CONCLUSIONS

- The structural behaviors of the repaired beams by adhesive materials are similar to that of original beams. Failures in both cases are characterized by diagonal crack on shear span and flexural crack on mid-span
- The repaired beams showed lower stiffness and greater ductility compared to the original beams.
- Among the three adhesive resin materials used for repairing, Epoxy bonding agent was more economy, because it repaired major diagonal cracks that did not reopen and the repaired beams failed due to formation of new major diagonal cracks.

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