RETROFITTING OF RCC BEAMS USING GLASS FIBER SHEET AND JUTE FIBER SHEET

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ABSTRACT

The Concrete Industry emerges with new development often involving significant changes in the material content making it adoptable to the changing conditions of requirement and availability. Retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion etc. Many of the existing reinforced concrete structures throughout the world are in urgent need of rehabilitation, repair or reconstruction because of deterioration due to various factors like corrosion, lack of detailing, failure of bonding between beam-column joints etc. Glass Fiber Polymer composite has been accepted in the construction industry as a promising substitute for repairing and in increment length strength of RCC structures. This paper presents an experimental study on reinforced concrete beams retrofitted with glass fiber polymer sheet and jute fiber sheet externally. The objective of this study is to investigate the behavior of beams after retrofitting using natural and syntheticfibers like jute fibers, glass fiberspolymer sheet. Beam specimen of size 1000×150×150mm was casted. An attempt has been made to study the flexural behaviour.

Keywords: *Retrofitting, Glass fiber, Jute fiber*

1. INTRODUCTION

Building materials form the backbone of civil engineering construction. Considering all the modern building materials, concrete is one of the oldest, but most versatile materials, with an annual worldwide production of over 4.5 billion metric tones. It is a manufactured material that can, with appropriate knowledge, be tailored for optimum performance when compared with other construction materials. It possesses many advantages including relatively good compressive strength, low cost, general availability ofraw materials, adaptability, low energy requirement, and utilization under different environment conditions.

Many of the existing reinforced concrete structures throughout the world are in urgent need of rehabilitation, repair or reconstruction because of deterioration due to various factors like corrosion, lack of detailing, failure of bonding between beam-column joints etc. Glass fiber polymer has been accepted in the construction industry as a promising substitute for repairing and in incrementing the strength of RCC structures. This paper presents an experimental study on reinforced concrete beams retrofitted with glassfiber sheet and jute fiber sheet externally. The objective of this study is to investigate the behavior of beams after retrofitting using natural fiber(jute fiber) and synthetic fiber(glass fiber).

To meet up the requirements of advance infra-structure new innovative materials/ technologies in civil engineering industry has started to make its way. Any technology or material has its limitations and to meet the new requirements new technologies have to be invented and used. With structures becoming old and the increasing bar for the constructed buildings the old buildings have started to show a serious need of additional retrofits to increase their durability and life. Many environmental and natural disasters, earthquake being the most affecting of all, has also produced a need to increase the present safety levels in buildings. The understanding of the earthquakes, world over, is increasing day by day and therefore the seismic demands imposed on the structures get revised frequently. Similarly, the design methodologies evolve with the growing research in the area of seismic engineering and certain popular old design philosophies, such as soft storey structures, are no longer considered acceptable for earthquake resistant design. Many of the existing lifeline structures were analysed, designed and detailed as per the recommendations of then prevalent codes. Such structures, pose a need to undergo re-evaluation process, say, every ten years. Such structures frequently may not qualify to current seismic requirements and therefore, retrofitting of these structures is essential. The retrofitting is one of the best options to make an existing inadequate building safe against future probable earthquake or other environmental forces. There are many other factors, considered in decision making for any retrofitting strategy.

The following are some reasons that may need retrofitting:

1. Building which are designed considering gravity loads only.

2. Development activities in the field of Earthquake Resistant Design (EQRD) of buildings and other structures result into change in design concepts.

3. Lack of timely revisions of codes of practice and standards.

4. Lack of revisions in seismic zone map of country.

5. In cases of alterations in buildings in seismic prone area i.e. increase in number of story, increase in loading class etc.

6. In cases of deterioration of Earthquake (EQ) forces resistant level of building e.g. decrease in strength of construction material due to decay, fire damage, and settlement of foundations.

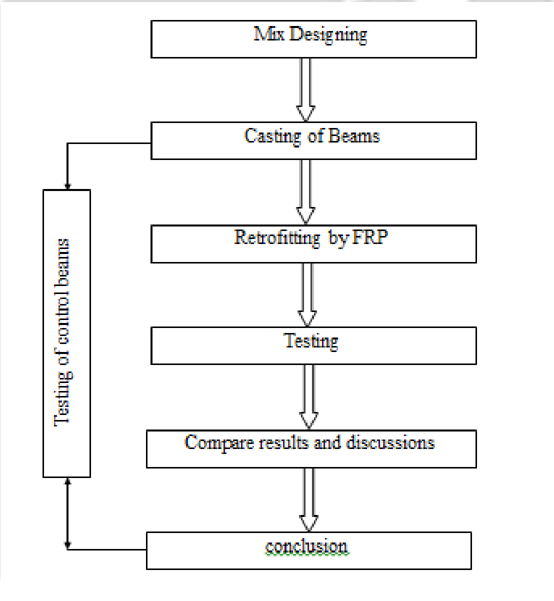
7. The quality of construction actually achieved may be lower than what was originally planned.

8. Lack of understanding by the designer.

9. Improper planning and mass distribution on floors.

Many options for retrofitting a structure are possible; the ones which are used traditionally for a long time now such as addition of new shear walls, addition Of infill walls, addition of wing (Side)Walls, addition of Buttresses, Jacketing Of Reinforced Concrete Members, Propping up, Sleeving, Steel collars, Casing, Building up, Bonding Steel Plates or Steel Jacketing. However, with increase in research and introduction of new materials and technology there are new ways of retrofitting the structure with many added advantages. Introduction of Fibre Reinforced Composites being one of them. It has proved to be a promising material and technology in repairs and retrofitting.

2. METHODOLOGY



3. MATERIALS

Ordinary Portland Cement of Grade 53 satisfying the requirements of IS 12269-1987 was used for the investigation. The initial setting time of cement was 30 minutes with a specific gravity of3.15. It was tested for its physical properties as per Indian Standard specifications. The fine aggregate used in this investigation was clear river sand passing through 4.75 mm sieve with a specific gravity of 2.62. The grading zone of aggregate was Zone II as per Indian Standard specifications. Machine crushed broken stone in angular shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm and its specific gravity was 2.87. Ordinary clean potable water free from suspended particles and chemical substances was used for both mixing and curing of concrete. Design concrete mix of 1:1.26:2.4 by weight is used to achieve the strength of 40 N/mm2. The water cement ratio of 0.4 was used. Three cube specimens were cast and tested (at the age of 28 days) to determine the compressive strength. The average compressive strength of the concrete was 26.87 N/mm2. Mild steel bars of 8 mm diameter were used as longitudinal reinforcement and 6 mm diameter bars were used for shear reinforcement.

4. CASTING OF BEAMS

The moulds were prepared using plywood. The dimensions of all the specimens were identical. The length of beams was 1000mm and the cross sectional dimensions were 150 mm x 150 mm. The design mix ratio was adopted for designing the beam. Nine under reinforced beams were cast, there as control specimens and six beams for retrofitting. Three bars of 8 mm diameter were provided as tension reinforcement at the soffit of the beam and bars of 6 mm diameter were provided as shear reinforcement.

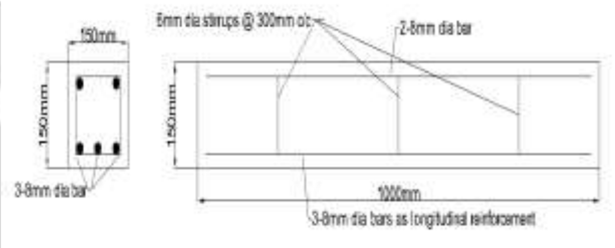


Fig 1 Reinforcement detailing of the beam

5. RETROFITTING OF BEAMS

The full wrapping technique around all the four sides of the beam is used as the method of retrofitting. At the time of bonding of fiber, the concrete surface is made rough using a wire brush and then cleaned with water to remove all dirt and debris. The beams are allowed to dry for 24 hours. The fibre sheets are cut according to their size. After that, the epoxy resin primer is mixed in accordance with manufacturer"s instructions. The mixing is carried out in a plastic container (Base: Hardener = 4Kg : 2 Kg). After uniform mixing, the epoxy resin primer is applied to the concrete surface. The beams are allowed to cure for 8 hours. The epoxy matrix is mixed in a plastic container in accordance with the manufacturer"s instructions to produce a uniform mix of base and hardener (Base : Hardener = 3.7 : 1.3). The coating is applied on the beams and fibre sheets for effective bonding of the sheets with the concrete surface. Then the fibre sheet is placed on top of epoxy resin coating and the resin is squeezed through the roving of the fabric. Air bubbles entrapped at the epoxy/concrete or epoxy/fabric interface are eliminated. During hardening of the epoxy, a pressure is applied on the composite fabric surface in order to extrude the excess epoxy resin and to ensure good contact between the epoxy, the concrete and the fabric. This operation is carried out at room temperature. Concrete beams strengthened with fiber sheets are cured for 3 days at room temperature before testing.

Fig 2 Mixing of epoxy resins

Fig 3 Beam wrapped using jute fiber sheet

Fig 4 Beam wrapped using jute fiber sheet

6. TESTING OF BEAMS

This section deals with analysis of results of the experimental investigations on the performance of RCC beam of control specimen and the retrofitted beams. Experimental investigation was carried out to determine the ultimate load, deflection of specimens. Load was applied on the beam specimens on centre points. The size of specimens was 1000mm x 150mm x 150mm. A computerised load frame Machine was used to obtain the ultimate load and deflection. Deflection of beam is noted when initial cracks appears on the beam. Deflectometer is used to determine the deflection of the beams.

Fig 5 Experimental test set up

Nine sets of beams were tested for their ultimate strengths. It is found that all the beams were failed in flexure. It is observed that the control beam had less load carrying capacity and high deflection values compared to that of the externally strengthened beams using GFS and jute fiber sheet.

Fig 6 View of load applied on wrapped glass fiber specimen

Fig 7 View of load applied on wrapped jute fiber specimen

Fig 8 View of visible crack on the control specimen and retrofitted beams

Since the full wrapping technique is used for retrofitting, initial cracks are not visible. Further with increase in loading, propagation of the cracks took place but it had poor visibility of cracks due to the covering of the glass fiber sheet and jute fiber sheets. The beams retrofitted with glass fibersheet had the maximum deflections and lower ultimate load carrying capacity. From the graph it is clear that all the retrofitted beams have better load deflection characteristics than the control specimen

Table 1 Average ultimate loads of different beams.

Description	Control specimen	Retrofitted beams with jute fiber sheet	Retrofitted beam with glass fibre sheet
Average ultimate load	55.67KN	74.51KN	104.76KN

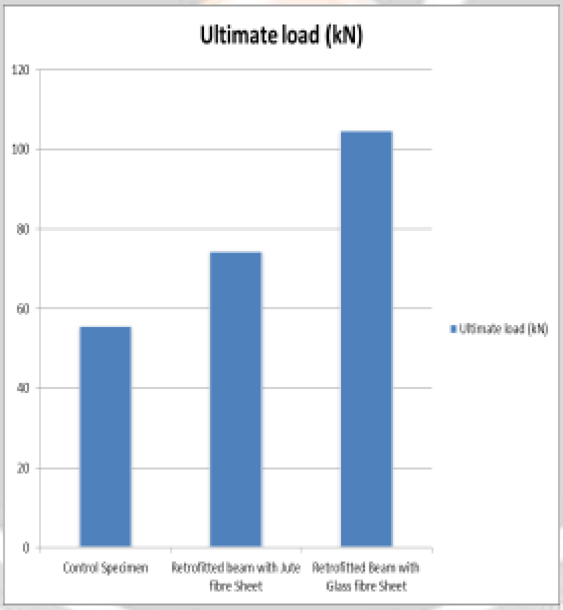


Fig 10 Comparison of ultimate load capacity

Retrofitting of beams enhances the ultimate load capacity of the beams. The control specimen had an ultimate load of 55.67KN, whereas all the retrofitted beams had an ultimate load greater than 70 KN.

Glass fiber sheet retrofitted beams had an ultimate load of 104.76 KN, and jute fiber sheet retrofitted beams has 74.51KN. Among the two sets of retrofitted beams, the beams retrofitted with jute fiber sheet had the least ultimate load carrying capacity and the value is 74.51 KN, which is greater than the ultimate load capacity of control specimen.

7. CONCLUSION

In this experimental investigation of flexural behaviour of reinforced concrete beams externally strengthened by glass fiber polymer and jute fiber sheets are studied. From the test results and calculated strength values, the following conclusions are drawn:

- The deflections of the beams are minimized due to full wrapping technique around all the four sides of the beam.
- The initial cracks in the strengthened beams appear at a higher load compared to the un-strengthened control beam.
- The flexural strength and ultimate load capacity of the beams improved due to external strengthening of beams.
- The strengthening of beams using glass fiber polymer sheets is found to be more effective in improving the flexural strength and ultimate load capacity.
- Retrofitted beam wrapped with jute fiber sheet also gives more strength comparing to control specimen beams. Jute fiber is a naturalfiber in which it may also used for retrofitting in a economical way.
- Comparing glass fiber sheet and jute fiber sheet, glass fiber sheet gives more effective strength for retrofitting.

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