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Rehabilitation of Reinforced Concrete Beams Using Basalt Fibre Wrappings

Aparna V. & Nithin Mohan

Abstract – Deterioration of RC structures is one of the major problem that the world facing. Thus the need of rehabilitation or reconstruction arises. Rehabilitation is more economical and sustainable than reconstruction. This experimental study deals with the rehabilitation of RC beams using the Basalt Fibre Wrappings. Basalt fibre has good tensile strength, fire resistance and economical. RCC beams of size 3200x150x200 mm are initially prepared. Then the beams are subjected to two point loading in order to highlight the study on the flexural behaviour of beams. Beams except control beams are preloaded upto 80% of failure load of control beams and strengthened with Basalt Fibre Wrapping. The strengthened beams are again subjected to two point loading. The retrofitted beams are later compared with the results of control beams. The effectiveness are studied using two different wrapping profiles, U shape wrapping and bottom wrapping.

Index Terms—: Basalt fibre wrappings, Flexure, Preload, Rehabilitation, Wrapping profiles, U Shape Wrapping, Bottom Layer Wrapping, Single Layer.

1. INTRODUCTION

Concrete structures in future will face structural deterioration. So the solution normally provided were reconstruction or rehabilitation if possible. Rehabilitation of reinforced concrete structures is often more economical and sustainable (less cement consumption, less CO2 production) than reconstruction. The use of composites for strengthening and repairing concrete structures has gained significant importance in civil engineering.

Textile reinforcement is a new technology of composite material which can even replace reinforcement to some extent. The use of Textile reinforcement is a common method for retrofitting of concrete structures. The commonly used FRP has some drawbacks in strength concern. Textile Reinforced Concrete (TRC) can overcome these drawbacks. These textile reinforcement comprises Jute, Glass fibres, Basalt fibres, Nylons etc are the most commonly used fabric meshes.

TRC is a composite material consisting of a matrix with a minimum aggregate size between 1 and 2 mm. Despite the fact that it is an expensive method, their high tensile strength and their good resistance to corrosion makes them a good choice for a retrofitting material. The stress strain diagram of TRC is similar to conventional reinforced concrete. Textile reinforcement have a number of applications in the field of civil engineering.

The purpose of this research was to investigate flexural behavior of retrofitted beams and control beams. The beam sections used in this research is of size 150 x 250 mm and of 3200mm in length. The beam is tested using two point loading & some partially loaded. The partially loaded beam is repaired using retrofitting method with basalt textile mesh. The retrofitted beam is then again tested. Flexural strength was determined and crack pattern studies were carried out. The effectiveness of various profiles of wrapping is studied and maximum load comparison is made.

- *Aparna V., currently pursing master's degree in Structural Engineering, Vidya Academy of Science and Technology, Thrissur, Kerala. e-mail: aparnasubhash285@gmail.com*
- *Nithin Mohan, Assistant Professor, CE Dept., Vidya Academy of Science And Technology, Thrissur, Kerala.*
  e-mail: nithin.n@vidyaacademy.ac.in

1.2 Scope of the project:

The study is to be carried out by incorporating Basalt textile fabric meshes The concrete section to be used for the study are of dimension 150x200x3200mm in beams. The experiment is to be done with M25 concrete. Two types of wrapping profiles are used: U Shaped & bottom layer wrapping.

1.3 Basalt Fabric Sheets

Basalt textile meshes is used here for retrofitting of RC beams. Basalt mesh Geo grid is available in different sizes with epoxy coatings for concrete and composites and asphalt coatings for asphalt reinforcement. Figure 1 shows the Basalt Fibre Sheet.

Basalt mesh is better than steel for many reasons

- Stronger than steel wire of comparable size
- Far lighter and easier to handle and install (no nasty cuts)
- Will not rust or corrode or cause cracking of concrete
- Flexible for easier design
- Does not conduct electricity or induce electric field
- It binds well with asphalt and concrete

Basalt fiber geo grid mesh is used for reinforcing asphalt concrete (covering in construction, reconstruction and repair of airport, runways, highways and any pavements, pedestrian ways, road inclines and banks). The reinforcement with basalt mesh increases the overall reliability, safety and the cutting process output. The strength of basalt mesh is as good metal reinforcement; however it is 2.6 times lighter, thereby simplifying transportation and handling in construction. It is more durable than metallic and glass fiber reinforcement due to its excellent performance.

FIGURE 1
BASALT FIBRE SHEET

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2 MATERIAL PROPERTIES

Properties of materials used in this study were obtained either by testing of the corresponding material or by referring the user's manual provided by the Manufacturer. PPC and M sand are used in this project. The coarse aggregate used is 20mm in size. The properties of cement, fine aggregate, coarse aggregate, Basalt fibre mesh used are given in Table 1,2,3,4 respectively.
As the water actively participates in the chemical reaction with cement water is considered as an important ingredient of concrete. It helps to form cement gel which imparts strength to the concrete. The quantity and quality of water should be very carefully inspected and it should be free from any foreign materials. Potable drinking water having pH value ranging between 6 and 8 can be used for construction. Therefore water used for this project was potable water free from impurities.

TABLE 1
PROPERTIES OF CEMENT

PROPRETIES OF CEMENT	
Specific gravity	2.95
Fineness	8%
Consistency	36%
Initial setting time	68 minutes
Final setting time	225 minutes

TABLE 2
PROPERTIES OF FINE AGGREGATE

PROPERTIES OF FINE AGGREGATE	
Specific gravity	2.75
Water absorption	1%
Fineness modulus	2.64
Grading zone	II

TABLE 3
PROPERTIES OF COARSE AGGREGATE

PROPERTIES OF COARSE AGREGATE	
Specific gravity	2.8
Water absorption	1%

TABLE 4
PROPERTIES OF BASALT FIBRE MESH

MATERIAL CHARACTERISTICS	BASALT FIBER CHARACTERISTICS
Density(g/cm)	2.67
Coefficient of thermal expansion	8
Tensile strength	48.4
Elastic modulus	898
Poisson ratio	.26

3 MIX DESIGN

Casting of concrete specimens was done as per Indian Standards. M25 mix was chosen and done mix design. Mix ratio obtained was 0.49: 1: 1.67: 2.8. Cubes of standard sizes are casted using the mix design After 28 days of curing the compressive strength of cubes were found out. The test was done in Compressive Testing Machine. The compressive strength of cubes of required mix was 29.89 kN/m^2. Figure 2 and 3 indicate the cubes during casting and demoulding.

FIGURE 2
CASTING OF CUBES

FIGURE 3
DEMOULDED CUBES

4 SPECIMEN CASTING

Using required mix beam design was done. Rectangular beams are casted with required sizes. Figure 4 represents the cross section of beam. The mould is made of Plywood. All the beams are casted with steel bars of grade 415 and size of the steel bar is 8mm for main reinforcement. Place the reinforcement cage in to the mould with a cover of 25mm is provided and a cover block is used for it. Pour the concrete in to the mould and compact the specimen by needle vibrator. Jute bags are used for curing, shown in Figure 5.

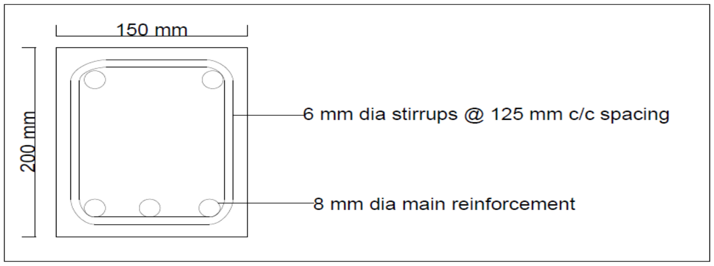

FIGURE 4
DESIGN DETAILS OF BEAM

FIGURE 5
CURING OF BEAMS

5 TEST SETUP

To study the behaviour of beams under pure flexure, two - point loading system are used on the beams after 28 days of curing. Control beams are tested upto failure and the load deflection curve is plotted. Beams to be retrofitted are loaded 80% of ultimate load. Figure 5 represents the schematic representation of two point loading set up. The surfaces of beams are provided with a single coat of white cement for the clear visibility of cracks. For giving two – point loading, an I section and 2 rods of 50mm diameter and 500mm length were used as shown in Figure 6. The laboratory setup of two pint loading is shown in Figure 7. The laboratory test setup of beam is represented in Figure 8.

6 RETROFITTING

The wrapping technique around the 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 the 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. 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. 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 28 days at room temperature before testing. Figure 9 and 10 represents retrofitting of partially loaded beams.

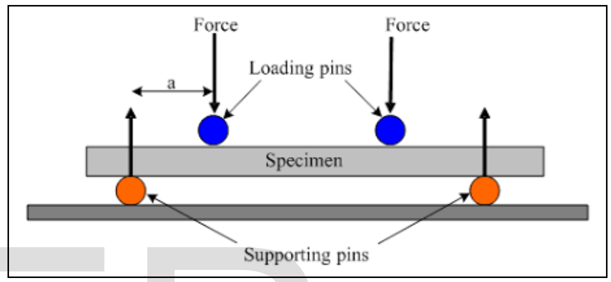

FIGURE 6
TWO POINT LOADING

FIGURE 7
TWO POINT LOADING

FIGURE 8
TEST SETUP OF BEAM

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FIGURE 9
EPOXY COATING ON SURFACE OF BEAM

FIGURE 10
WRAPPING WITH BASALT FIBRE SHEET

Two types of wrapping methods are used here. U Shaped wrapping and bottom layer wrapping. The schematic representation of those wrappings is given in Figure 11 and 12.

FIGURE 11
U SHAPED WRAPPING

FIGURE 12
BOTTOM LAYER WRAPPING

7 RESULTS AND DISCUSSION

The control beams and preloaded beams are tested by two - point loading. Initially flexure cracks are formed from bottom of beams and shown in Figure 13. The results of the tests are shown in following figures. Figure 14 shows the moment deflection curve of control beam. The ultimate moment capacity of the control beam tested is 19.8 kNm. The beams to be retrofitted are partially loaded 0.8 times of ultimate moment. Two specimens were considered for each case and the moment deflection curve is plotted in Figures 15 and 16. The mean ultimate moment of U shape wrapped beam is 27.2 kNm and for bottom layer wrapping is 23.1kNm. The comparison of the wrapping with control beams are shown in Figure 17 and 18. The moment deflection curves shows that retrofitted beams show much higher moment capacity. From these resutls, the U shape wrapped beam shows better performance compared to control beams and bottom layer wrapped beams.

FIGURE 13
CRACKS ON BEAM

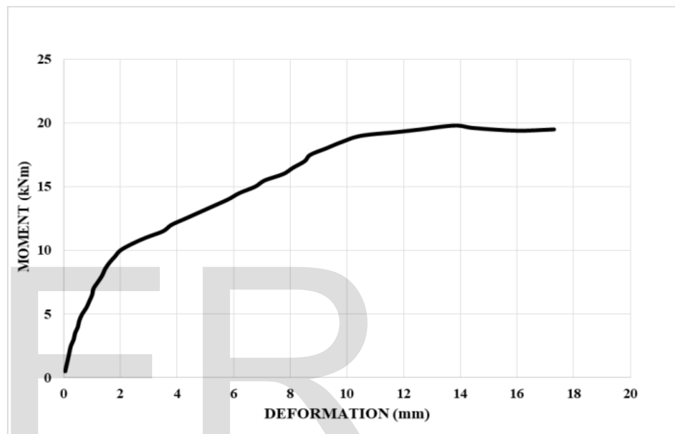

FIGURE 14
MOMENT DEFLECTION CURVE OF CONTROL BEAM

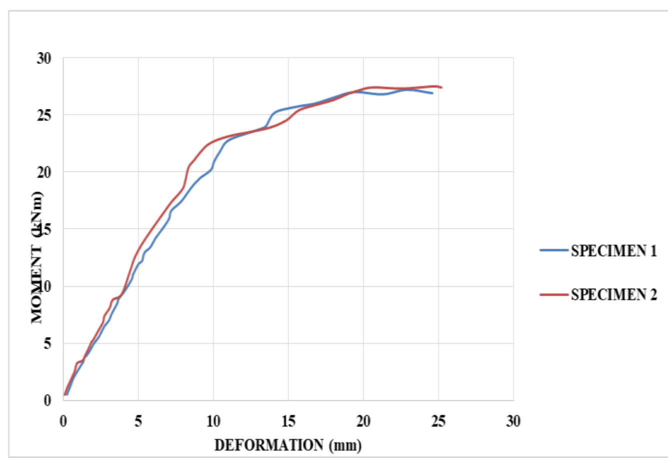

FIGURE 15
MOMENT DEFLECTION CURVE OF U SHAPE WRAPPED BEAMS

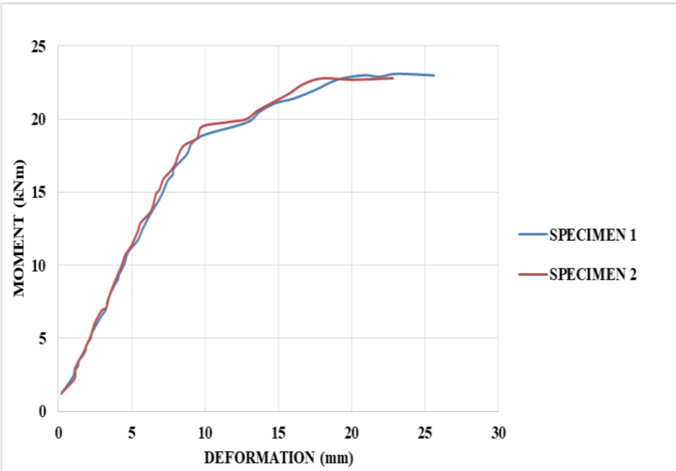

FIGURE 16
MOMENT DEFLECTION CURVE OF BOTTOM LAYER WRAPPED BEAMS

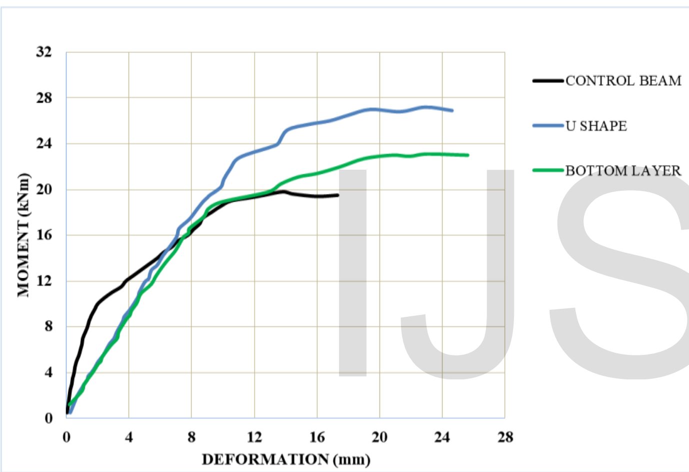

FIGURE 17
COMPARISON OF MOMET DEFLECION CURVE

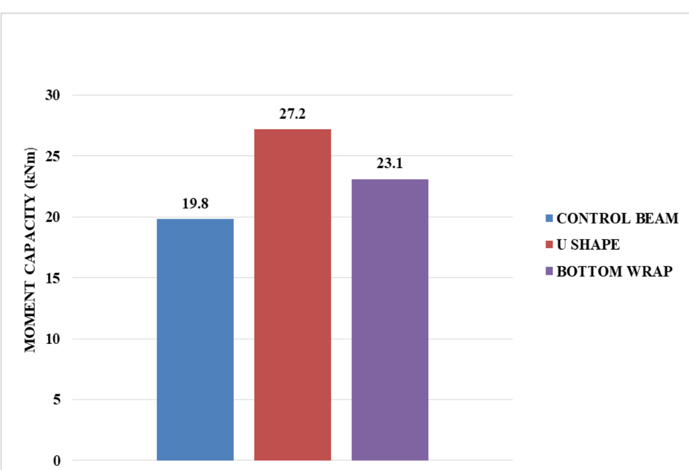

FIGURE 18
COMPARISON OF MOMENT CAPACITY

8 CONCLUSIONS

Based on experimental investigations the flexural behaviour of reinforced concrete beams externally strengthened by basalt fiber is studied. From the test results and calculated strength values the following conclusions are drawn

(i) Basalt fabric was found effective in improving the flexural toughness of RC beams.

(ii) The strengthened beams showed a remarkable increase in the flexural toughness.

(iii) Retrofitting of control specimen using basalt textile mesh is effective as the flexural strength of the control specimen is increased.

(iv) Out of the two different profiles for strengthening, such as, the bottom layer wrapping & U shape wrapping, the U shape wrapping was found more effective.

(v) In bottom layer bonding the flexural strength is increased by 20-25%.

(vi) In U shape wrapping bonding the flexural strength is increased by 30-35%.

The failure of the control specimen is a flexural failure. Crushing of concrete takes place at the top and at the bottom yielding of rebar occurs. From the above conclusions, it can be summarised that the textile reinforcement can be used according to the needs and requirement with some additions and modifications for better strength.

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