A STUDY ON THE STRENGTHENING OF RC BEAMS USING TEXTILE REINFORCEMENT

P.B Jayakrishnan[1],Paul Shaji[2]

[1]PG Student, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India

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Abstract - *Textile reinforcement concrete is a new technology of composite material which can even replace reinforcement to some extent. Textile reinforcement is a common method for retrofitting of concrete structures. These textile reinforcement comprises fabric meshes. Jute, glass fibres, Nylons etc are the most commonly used fabric meshes . This project is mainly concerned on the strengthening of concrete structures by providing textile reinforcement. The beam sections used in this research is of size 150 x 250 mm and of 1500mm in length. The beam is designed for 5 ton. When 50KN is applied to the beam, it will fail. After failure the beam is repaired using retrofitting method with basalt textile mesh. Some beams are retrofitted before applying load and a comparison in strength of beam before and after using basalt mesh is studied.. Flexural strength was determined and crack pattern studies were carried out.The effectiveness of various profiles of wrappind is studied and maximum deflection and maximum load comparison is made.*

Key Words: (Textile reinforced concrete, Fibre reinforced mortar, Textiles, Compressive Strength, Flexural Strength, Textile reinforced mortar

1.INTRODUCTION

Textile reinforcement is now being a common method for retrofitting of concrete structures. Textiles comprise fabric meshes made of long woven, knitted or even unwoven fibre rovings in at least two (typically orthogonal) directions. Mortarsin which the textile reinforcement is embedded serve as binders containing polymeric additives inorder to have improved strength properties. Materials with high tensile strengths with negligible elongation properties are reinforced with woven or unwoven fabrics. The fibres used for making the fabric are of high tenacitylike Jute, Glass, Fibre, Kevlar, Polypropylene, Polyamides (Nylon) etc.

1.1 Need for textile reinforcement

The use of fibre reinforced polymers (FRP) in strengthening and retrofitting projects has gained increasing popularity among structural engineers, due to numerous attractive features of these materials, such as: high specific strength (i.e. strength to weight ratio), corrosion resistance, ease and speed of application and minimal change of cross sections. Despite its advantages over other methods, the FRP strengthening technique is not entirely problem-free. The organic resins used as to bind and impregnate the fibres entail a number of drawbacks, namely: (a) poor behaviour at temperatures above the glass transition temperature; (b) relatively high cost of resins; (c) potential hazards for the manual worker; One possible course of action aiming at the solution of the drawbacks of FRP would be the replacement of organic binders with inorganic ones, e.g. cement based mortars, leading to the substitution of FRP with fibre reinforced mortars (FRM). The problem arising from such a substitution would be the relatively poor bond conditions in the resulting cementitious composite as, due to the granularity of the mortar. Fibre matrix interactions could be enhanced when continuous fibre sheets are replaced by TEXTILES. The latter comprise fabric meshes made of long woven, knitted or even unwoven fibre rovings in at least two (typically orthogonal) directions. The quantity and the spacing of rovings in each direction can be controlled independently, thus affecting the mechanical characteristics of the textile and the degree of penetration of the mortar matrix through the mesh openings. It is through this mechanical interlock that an effective composite action of the mortar-grid structure is achieved. For the cementitious matrix, the following requirements should be met: non-shrinkable; high workability; high viscosity; low rate of workability loss (application of each mortar layer should be possible while the previous one is still in a fresh state); and sufficient shear (hence tensile) strength, in order to avoid premature debonding.

1.2 Textile reinforced concrete

An alternative strengthening material that has become of interest as of late is Textile Reinforced Concrete (TRC). This state-of the art composite material can be used in new structures, as well as in strengthening of beams, slabs, columns and even walls. It is of particular interest to discuss TRC as a strengthening material in this study. In FRC, the principle is to insert short fibres in the concrete matrix. These fibres could be metallic (steel), mineral (glass), natural (cellulose, Jute, etc.) or polymeric (acrylic, aramid, carbon, nylon, etc.). TRC is a composite material consisting of a matrix with a minimum aggregate size between 1 and 2mm and high-performance, continuous multifilament yarns made of alkali resistant (AR) glass, carbon or polymer.One important difference between TRC and FRC is that the short fibres in FRC are oriented in all directions, when the textile fibres in TRC behave like a normal steel reinforcement, with the exact orientation to support the efforts. This results in higher strengths for TRC than in FRC.

2. TEXTILE MATERIALS

Textile fibres have a great influence on the strength of composite materials, their properties as well as their magnitude. Materials which are most applicable for use in TRC structures are alkali-resistant glass (AR-glass), carbon and aramid fibres. Besides these materials, basalt, steel and polymer fibres such as PBO can also be used. Steel fibre yarns are however not economically feasible. Comparisons between them are shown below in Table 1.

Table -1

Textile	Diameter range (μm)	Density (kN/m³)	Tensile strength (GPa)	Young's modulus (GPa)	Advantages	Disadvantages
AR–glass	9 to 27	2800	1.4	70 to 80	Very good adhesion to concrete	Low tensile strength
Carbon	7	1800	2 to 5	200 to 450	Superior tensile strength	Expensive
Aramid	12	1400	3	60 to 130	Low density low brittleness	Negative heat expansion, low resistance to alkali attacks
Basalt	9 to 13	2600	2.99	95	High elongation and equivalent thickness	Expensive
PBO	8	2445	5.80	270	High strength	Expensive

From the above table, it is clear that these fibres have great strengthening capacity. Their high tensile strength and their good resistance to corrosion, for example, make them a good choice for a reinforcing material. Despite the fact that they remain expensive and present some challenges in regards to production, these fibres nevertheless are reasonable alternatives to traditional steel bars or short fibres.

2.2 Concrete matrix

The concrete used for TRC needs to fulfil demands, mechanical properties and durability, which are necessary to get proper composite material behaviour. Usually the maximum grain size used is less than 2mm, thus the concrete matrix is also called fine-grained concrete. Matrix composition should have chemical compatibility with textile reinforced materials, consistency for full penetration, planned production process and mechanical properties for load-carrying capacity of a TRC element

2.3 Basalt fabric meshes

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.

Basalt mesh is better than steel for many reasons

- Stronger than steel wire of comparable size
- Far lighter and easier to handle and install
- 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, pedestrain 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.

3 BEAM CASTING

Fourteen Beams were casted with standard mould having cross section 150x250mm and length 1500mm. The mould is made of Plywood. All the beams were casted with steel bars of grade 500 and size of the steel bar is 12mm. Concrete mix used for casting of beam is M25. Place the reinforcement cage in to the mould .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.

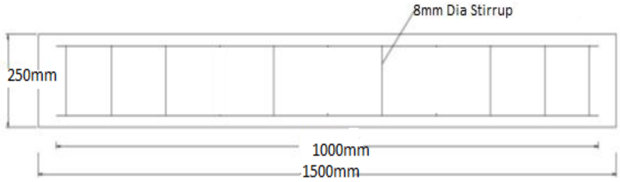

Fig 1: Longitudinal section of the beam

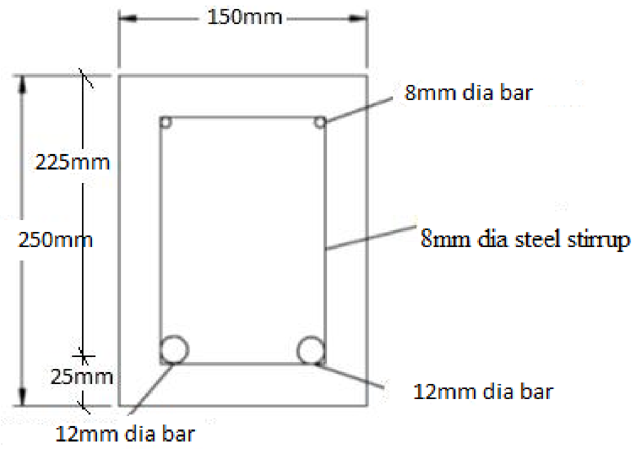

Fig 2: Beam reinforced with steel rebar

3.1 Testing of beams

The specimens casted were tested for their failure load using loading frame of capacity 5 ton after 28 days The apparatus used for testing the specimen is a loading frame of capacity 10 tonnes.the loading frame consisted of steel frames to transfer the load to foundation and pumps and jack to apply the load to specimen. There was only one type of jack available in the labouratory and it was of capactity 10 ton.

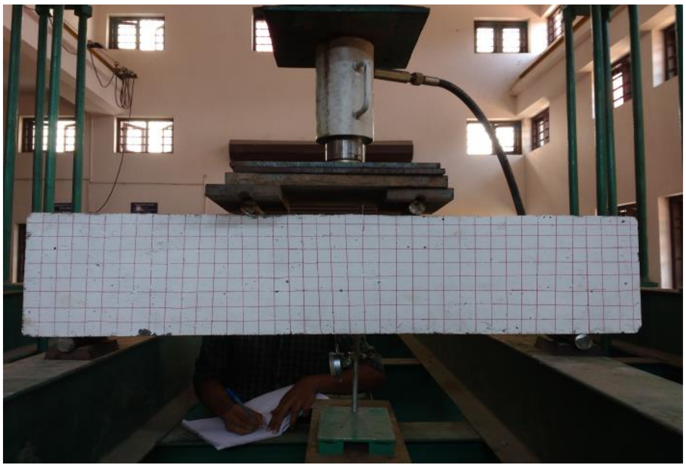

Fig 3 : Loading aarangement of the specimen

3.2 Failure load

The specimen casted were tested for their failure load .the specimens were placed on the loading frame with two end simply supported. The load was applied manualy at a constant rate without shock. For testing of beams, hydraulic jack of 10Ton capacity was used and a plate section was placed below the jack and 2 rollers were placed below the plate sections for uniformly transfering the load throughout the beam. The beams were placed above the I section with roller support at distance 75mm from both ends, beam was placed over the roller support, spacing between the rollers is 1000mm.load is applied corresponding deflections are measured till the beam fails. load applied was measured using a dial gauge with 0.01T accuracy.

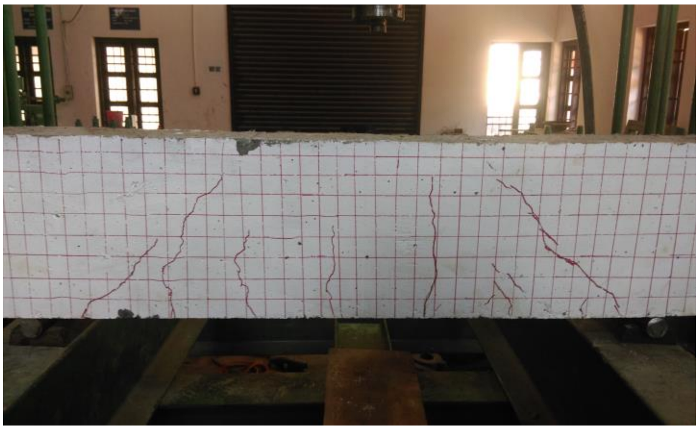

Fig 4: Crack pattern after loading

3.3 Retrofitting of RC 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 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 withmanufacturer"s instructions. The mixing is carried outin 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 andhardener (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 arecured for 3 days at room temperature before testing.

Fig 5: Fixing the basalt mesh over the beam using epox resin

4. Test results

We have tested the beams and noted the various loads and their corresponding deflections. 7.4 KN ia the ultimate load of the control specimen. After retrofitting this control specimen with basalt textile mesh using epoxy resin , the ultimate load was found to be 9.4KN. Also comparison has been made on their strength and deformations.

	Control specimen		Control specimen after retrofitting with basalt textile mesh	
Sl.no	Load(KN)	Deflection(mm)	Load(KN)	Deflection(mm)
1	10	.53	10	.27
2	20	.84	20	.49
3	30	1.25	30	.93
4	40	2.98	40	1.42
5	50	4.2	50	3.87
6	60	6.32	60	4.9
7	Ultimate(61)	7.4	70	6.48
8			80	8.9
9			Ultimate(82)	9.4

Table 1: Load and corresponding deflection values of control specimen before and after retrofitting

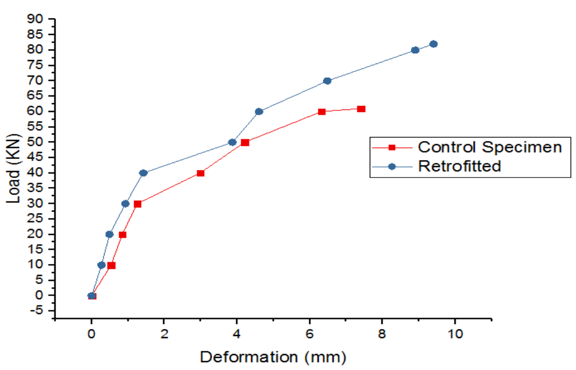

Fig 6: Strength comparison of beams using graph

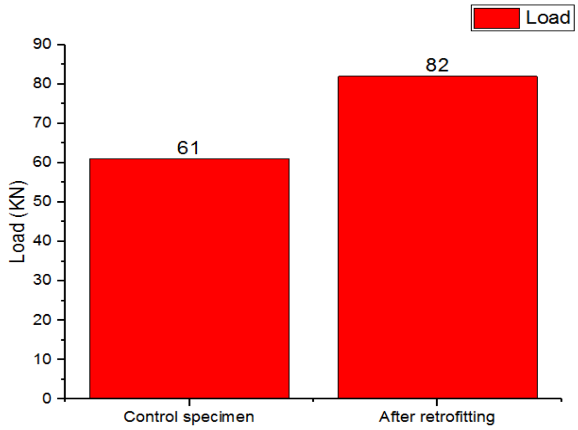

Fig 7: Strength comparison of control specimen

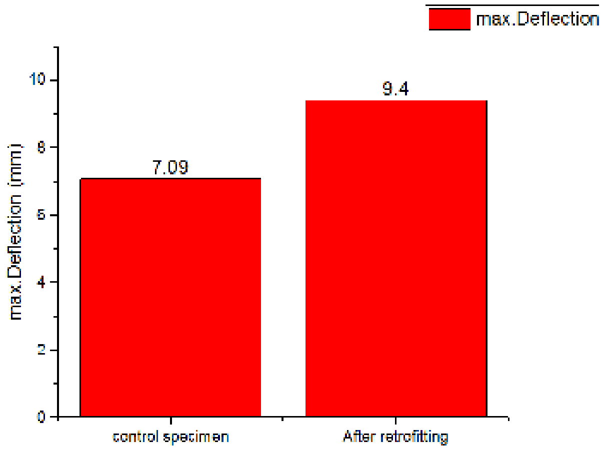

Fig 8: Deflection comparison of control specimen

5. CONCLUSION

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

1. The strengthened beams showed a remarkable increase in the flexural toughness.

2. Ductile failure was noticeable in comparison with the brittle failure of unstrengthened beam.

3. Retrofitting of control specimen using basalt textile mesh is effective as the flexural strength of the control specimen is increased by 30-35%.

4. On comparing the deformation of the control specimen before and after retrofitting , then the deformation is decreased by 25-30%.

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