Journal for Research | Volume 04 | Issue 02 | April 2018
ISSN: 2395-7549

Flexural Strength of GFRP Reinforced Beams

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Abstract

Glass fiber-reinforced polymer (GFRP) reinforcements are taken as an alternative solution for the deterioration of civil infrastructures. GFRP bars have received increasing attention due to low cost compared to carbon fiber-reinforced polymer (CFRP) bars. In this paper, Tweleve beams are casted in which six beams are casted with steel as main and shear reinforcement and another six beams are casted with GFRP as main reinforcement with steel as shear reinforcing material. All beams casted are of same dimensions. The size of the beams casted is of length 700 mm, breadth 150 mm and depth 150 mm. The clear cover of 25 mm is provided on top and bottom of the beam. Beams are tested under two-point loading with constant aspect ratio (a/d) and comparing the flexural strength, load deflection curves and types of failures of beams reinforced with GFRP as main reinforcement and beams reinforced with conventional steel. The final experimental results are compared with numerical results.
Keywords: Flexural Strength, Tensile Strength Concrete Beam, Fiber Reinforced Polymer (FRP), Ultimate Moment, Deflection

I. Introduction

Concrete is the most widely used construction material in the world today. High compressive strength of concrete makes it an ideal material for structure. However its tensile strength is not good as its compressive strength. Traditionally, steel reinforcing bars have been used in concrete to carry the internal tensile forces resulting from the application of external loads.

Though steel is very convenient material to take tension in reinforced concrete structures, in certain areas it is required to be replaced.

The corrosion problem occurs in the structures located in aggressive environments such as coastal and marine structures, chemical plants, water and wastewater treatment facilities and bridges. Corrosion of reinforcements can result in costly repairs and safety hazards. Rust from the corroded bar takes large volume than the iron from which it formed, resulting in expansive forces cracking and spalling of concrete and ultimately the failure of structure. Millions of rupees are spent every year to replace or repair concrete structures that are deteriorated due to the corrosive effect of salt. This problem is more serious in cold climate countries, where de-icing salts accelerate the deterioration. Reported figures to repair and maintain concrete structures deteriorated by corrosion of reinforcements are horrible. The eighth annual report of the Secretary of Transportation to the Congress of the USA reported that 40% of the 575,607 inventoried highway bridges are either structurally or functionally deficient. In Quebec (Canada) half of the maintenance budget of the Ministry of Transports is spent in repairing the concrete structures damaged by corrosion of steel. Within Europe the annual cost of corrosion has been estimated to be 1000 million pounds per year.

In areas where low electric conductivity or electromagnetic neutrality is needed, use of steel as reinforcement results in complex construction layout. Some possible areas are structures supporting electronic equipments such as transmission towers, airport control towers, hospitals, and military structures (invisibility to radar). In above structures, other suitable material can replace steel to avoid health hazard or to protect electronic equipments.

Hence, it is necessary to search a material by which steel can be replaced.

Development of engineering through the centuries is dependent on the discovery and availability of new structural materials. Society always continues to seek materials that are strong, tough, and durable. Hence, composite are developed. The idea of combining two or more materials with improved properties is quite old. Composite should have the combined advantages with superior performance in comparison with each individual material. We are proceeding towards polymer age from steel age. To achieve required strength we add steel fibres with blended concrete Therefore, polymer composites can be the alterative solution for steel.

Fiber reinforced polymer (FRP) composite is considered as a promising alternative to the traditional steel reinforcements because of its inherent corrosive resistance, though the long-term performance of some types of fibre in certain environments is still questionable. Other appealing characteristics of FRP include high tensile strength, good fatigue and damping response, high strength-to-weight ratio, and electromagnetic transparency. The wide-ranging application of FRP reinforcements, especially as a main reinforcement, however, has been rather limited. This may be partially due to the high initial cost of materials and the lack of design guidelines.

Though concrete is very convenient material but in certain it is necessary to use polymers in concrete, Incorporation of fibers in concrete has been found to improve several of its properties: tensile strength, cracking resistance, impacts and wears resistance, ductility and fatigue resistance.

High strength concrete (with compressive strength higher than 40 MPa) is being used in the construction buildings, and other reinforced and prestressed concrete structures. One major drawback of high strength concrete is that it is brittle. The failure will be sudden and catastrophic, particularly in structures, which are subjected to earthquake, blast or suddenly applied loads. An ideal solution to overcome the serious disadvantages of high strength concrete is to add fibres in the concrete to make a ductile material and avoid sudden failures. Lots of work has been carried out for flexural strength of beam. Thus, this dissertation is an attempt to find out the shear strength of GFRP reinforced FRC beam.

Polymerized fibre reinforced concrete composites are almost ideal materials for repair, rehabilitation, retrofit, and renovation of the world's deteriorating infrastructure.

Polypropylene Fibers are accepted by National Codes as an alternative method of secondary reinforcing to welded wire fabric – Non-magnetic, Rustproof – Alkali proof – Requires no minimum amount of cover – Is always positioned in compliance with codes – Safe and easy to use – Reduces construction time – Eliminates welded wire fabric hassle on the jobsite. Fibres the control of cracking due to drying shrinkage and thermal expansion/contraction, lowered permeability, increased impact capacity, shatter resistance, abrasion resistance and residual strength. By using these fibers mainly Ductility of concrete and Load carrying capacity of concrete is also increased.

II. OBJECTIVES

In subsequent dissertation Flexural strength of FRC Beam reinforced with GFRP bars are studied in details

1) To study papers written on similar research work. Success and failure of previous experimental work to be studied.
2) Non-corrosive GFRP rebars are to be used as an alternative to steel reinforcement to overcome the corrosion problem.
3) Although various solutions has been tried in the past to counter the threat of corrosion in steel reinforcement by using epoxy coatings, cathodic protection, increased concrete cover thickness, and polymer concrete, none of the measures has provided long-term solution.
4) Better cost-effective materials are needed to maintain and improve the infrastructure.
5) Alternatives to steels and alloys to combat the high costs of repair and maintenance of structures damaged by corrosion and heavy use.
6) GFRP materials behave differently from reinforcing steel in terms of bond. They are of non-homogeneous and an-isotropic. Due to this outstanding behavior, there is a difference in transfer of loads between GFRP bars and concrete which made it as an idealized choice of a material.

III. LITERATURE SURVEY

[1] "Bond mechanism and bond strength of GFRP bars to concrete" ; Composites Part B: Engineering,FeiYan, ZhibinLin, MijiaYang ,Volume 98, 1 August 2016, Pages 56-69

Glass fiber-reinforced polymer (GFRP) reinforcements are taken as an alternative solution for the deterioration of civil infrastructures. GFRP bars have received increasing attention due to low cost compared to carbon fiber-reinforced polymer (CFRP) bars. Bond characteristic of GFRP bars in concrete is the most critical parameter for implementation of the material to the corrosion-free concrete structures. Unlike steel reinforcement, GFRP materials behave anisotropic, non-homogeneous and linear elastic properties, which may result in different force transfer mechanism between reinforcement and concrete. With the purpose of covering the most valuable contributions regarding bond mechanism in the past work, a comprehensive review focusing on the failure mode and bond strength is carried out in this paper. A database consisted of 682 pullout-test specimens was created to observe the factors affecting bond behavior. Basic relationship between bond strength/slip and factors was analyzed accordingly. In addition, the development of bond degradation under environmental conditions, such as freezing-thawing cycling, wet-dry cycling, alkaline solutions and high temperature was presented thereafter. These environmental influences need to be further investigated.

[2] "Experimental Study On Flexural Behaviour Of Beams Reinforced With GFRP Rebars", G Naveen Kumar and Karthik Sundaravadivelu* School of Civil Engineering, SASTRA University, Thanjavur, 613401, India.(2017)

In saline, moisture and cold conditions corrosion of steel is inevitable and the lot of economy is used for rehabilitation works. Corrosion of steel is nothing but oxidation of iron in moisture conditions and this corrosion leads to the spalling of concrete which intern reduces the strength of the structure. To reduce this corrosion effects, new materials with resistance against corrosion have to be introduced. Many experiments are going on using Glass Fiber Reinforced Polymer (GFRP) as alternate material for steel due to its non-corrosive nature, weight of GFRP is nearly one third of steel and ultimate tensile strength is higher than steel. In this paper, six beams are casted in which three beams are casted with steel as main and shear reinforcement and another three beams are casted with GFRP as main reinforcement with steel as shear reinforcing material. All beams casted are of same dimensions with variation in reinforcement percentage. The size of the beams casted is of length 1200 mm, breadth 100 mm and depth 200 mm. The clear cover of 25 mm is provided on top and bottom of the beam. Beams are tested under two-point loading with constant aspect ratio (a/d) and comparing the flexural strength, load deflection curves and types of failures of beams reinforced with GFRP as main reinforcement and beams reinforced with conventional steel. The final experimental results are compared with numerical results. M30 grade concrete with Conplast as a superplasticizer is used for casting beams.

[3] H. Wang [13] and A. Belarbi “Flexural Behaviour of Fibre-Reinforced-Concrete Beams Reinforced with FRP Rebars”

The main objective of this study is to develop a nonferrous hybrid reinforcement system for concrete bridge decks by using continuous fibres-reinforced-polymer (FRP) rebars and discrete randomly distributed polypropylene fibres. This hybrid system has the potential to eliminate problems related to corrosion of steel reinforcement while providing requisite strength, stiffness, and desired ductility, which are shortcomings of the FRP reinforcement system in reinforced concrete structures. The overall study in plan includes (1) development of design procedures for an FRP/FRC hybrid reinforced bridge deck system; (2) laboratory studies of static and fatigue bond performance and ductility characteristics of the system; (3) accelerated durability tests of the hybrid system; and (4) static and fatigue tests on full-scale hybrid reinforced composite decks. This paper presents the results relating to the flexural behaviour of the polypropylene-fibre-reinforced-concrete beams reinforced with FRP rebars.

Test results indicated that with the addition of fibers, the flexural behavior was improved with an increase of ductility index by approximately 40% as compared to the plain concrete beams. Crack widths of FRP/FRC were found to be smaller than those of FRP/plain concrete system and the values predicted by the current ACI 440 equations. Furthermore, the compressive failure strains of concrete in FRP/FRC beams exceed the strain of 0.0040mm/mm.

IV. PROBLEM STATEMENT

1) To study and compare the flexural behavior of GFRP reinforced concrete beams, with Steel reinforced beams with a focus on evaluating current design code provisions relating to design with GFRP.
2) To Study the ultimate load Capacities, Deflection, Direct Tension, direct Compression on GFRP reinforced and Steel Reinforced beams.

To Study the bond strength of the GFRP and Steel embedded Cubes and their comparison tested by direct pull out test. To study and compare Ultimate load carrying Capacities at failure of Specimens reinforced with GFRP and Steel bars.

Although generally, FRP bars have lower weight, lower modulus of elasticity, but higher strength than steel. In the other hand, FRP has disadvantages, for instance: no yielding before brittle rupture and low transverse strength.

Results taken from the experimental tests are to be compared with ACI 440.

V. EXPERIMENTAL PROGRAM

A. Test for Flexure

1) Total Twelve beams will be casted in which six beams will be of steel as main and shear reinforcement and another six beams will be of GFRP as main reinforcement with steel as shear reinforcement in form of stirrups.
2) The size of the beams will be of 700 mm x 150 mm x 150 mm. The clear cover of 25 mm provided on top and bottom of the beam.
3) Beams will be tested under Two-point loading with constant aspect ratio (a/d) and comparing the flexural strength, load deflection curves, Direct Tension ,Direct compression and types of failures of beams reinforced with GFRP as main reinforcement and beams reinforced with conventional steel.
4) The final experimental results will be compared with numerical results. M25 grade concrete is used for casting beams.

B. Test for BOND

1) Total Six cubes will be cashed out of which Three Cubes will be embedded with GFRP bars and Three cubes will be Embedded with Steel bars and Subject to Direct tension Pull out test.
2) The size of cubes are of uniform size, ie. 150mm x 150mm x 150mm. With concrete grade M25 and bars of Steel and GFRP embedded into them.
3) To determine local bond slip relation experimentally between rebar and concrete, rebar placed at center in concrete are used for direct pullout tests.
4) Calculation of bond strength is based on load and results will be recorded at maximum load at failure of the specimen.

VI. CONCLUSION

1) Experimental results obtained for conventional beams are satisfied with theoretical values from IS 456-2000 but GFRP reinforced beams disagrees with IS 456-2000.
2) The extensive study indicates that great potential exist for use of GFRP rebars in concrete structures, especially in areas where corrosion is a problem.
3) Shear strength is less than flexural strength then there will be a shear failure.
4) Observed cracks in beam approximately at 45^o to the horizontal axis of the beam.
5) After ultimate load, load-carrying capacity reduces and constant for certain deflection then again it reduces and continued for a certain deflection thus after maximum load beams load-carrying capacity did come to end suddenly thus we can conclude the ductility of the beam is improved.
6) Shear capacity of concrete beam does not depend on the type of material but depends on cross section of the beam.
7) Adding 0.1 % of polypropylene fibre in design mix M25,the strength increases about 60 %
8) Fine cracks are not observed in GFRP reinforced FRC beams, because of fibres.
9) Thus, we can conclude that fibres are useful to reduce cracks in the concrete.

REFERENCES

[1] "Bond mechanism and bond strength of GFRP bars to concrete"Composites Part B: Engineering, FeiYan, ZhibinLin, MijiaYangVolume 98, 1 August 2016, Pages 56-69
[2] "Experimental Study On Flexural Behavior Of Beams Reinforced With GFRP Rebars", G Naveen Kumar and Karthik Sundaravadivelu* School of Civil Engineering, SASTRA University, Thanjavur, 613401, India.(2017)
[3] "Experimental and Theoretical Investigations on Bond Strength of GFRP Rebars in Normal and High Strength Concrete" ; P Eswanth and G Dhinakaran School of Civil Engineering, SASTRA University, Thanjavur 613401, India(2017).
[4] "Flexural behaviour of concrete elements reinforced by GFRP bars"; S.H. Allayed [22], T.H. Almusallam and Y.A. Al-Salloum (1995)non-metallic (FRP) reinforcement for concrete structures Rilem London.
[5] "Fiber reinforced cement composites". P.N.Balaguru [18] and S.P.Shah,.
[6] "Bending behaviour and deformability of GFRP concrete members"; P.V. Vijay [17] and Hota V.S. GangaRao (2001), ACI Structural Journal/December 2001.
[7] "Effects of FRP reinforcement ratio and concrete strength on flexural behaviour of concrete beams";Michele Teriault [15] and Brahim Benmokrane (1998), ACI Journal Feb. 1998
[8] "Flexural Behaviour of Fibre-Reinforced-Concrete Beams Reinforced with FRP Rebars", :H. Wang and A. Belarbi
[9] "Load Testing of GFRP Composite U-Shape Footbridge",Łukasz Pyrzowski 1, Mikołaj Miśkiewicz 1, Jacek Chróścielewski 1, Krzysztof Wilde 1 1 Gdansk University of Technology, Narutowicza 11/12, 80-233 Gdansk, Poland.(2017)