A Review on "Experimental analysis of deep beam strengthened by glass fiber reinforced polymer plate"

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Abstract - *This Review paper covers the study of deep beam and propsed to carry out the experimental work to check the feasibility and possibility of BFRP (Basalt fibre reinforced polymer) and bamboo to be used as reinforcement in a deep beam. In this paper objective of work and their methodology is suggested. The outcomes may lead to change a practice of material as reinforcement other than steel in RCC deep beam.*

Key Words: Deep beam ,glass fiber reinforced polymer, epoxy resin, hardner

1. INTRODUCTION

1.1 Deep beam

Deep beams are often used as structural members in Civil Engineering works. Because of the geometric proportions of deep beams, their strength is usually controlled by shear rather than flexure, if normal amounts of reinforcements are provided. Reinforced concrete (RC) deep beams are generally used as load-transferring elements, such as transfer girders folded plates, and foundation walls. In buildings, a deep beam or transfer girder is used when a lower column on the exterior façade is removed for architectural purposes. In construction, deep beams are widely used in water tanks, underground bunkers, silos, nuclear reactors, etc., where walls act as vertical beams spanning between column supports. Sometimes pile caps are also designed as deep beams. Indian Standard Code IS:456-2000 (page no.51 , clause no.29.1) the beams with span to depth ratios less than 2.5 for continuous span and less than 2.0 for simply supported span are considered as deep beams.

1.2 Glass Fiber Reinforced Polymer

FRP can be applied to strengthen the beams, columns, and slabs of buildings and bridges. It is possible to increase the strength of structural members even after they have been severely damaged due to loading conditions. In the case of damaged reinforced concrete members, this would first require the repair of the member by removing loose debris and filling in cavities and cracks with mortar or epoxy resin. Once the member is repaired, strengthening can be achieved through the wet hand lay-up process of impregnating the fiber sheets with epoxy resin then applying them to the cleaned and prepared surfaces of the member.

Glass fibers, also known commercially as 'fiberglass', are most extensively use reinforcements for polymer matrix composites due to their combination of low cost, high strength and relatively low density. Unlike carbon or Kevlar fibers glass fibers are isotropic thus avoiding loss of properties when loaded in the transverse direction. Fiberglass is produced by pulling molten glass through orifices at a temperature where the glass has just the right amount of viscosity.

1.3 Epoxy Resin

Epoxy resins are relatively low molecular weight pre-polymers capable of being processed under a variety of conditions. Epoxy resins are characterized by the presence of a three-membered ring containing two carbons and an oxygen (epoxy group or epoxide or oxirane ring).

2. RELEVANCE

In the area of repair and strengthening worked have been carried out on wrapping. The damaged bridge piers to prevent collapse and wrapping reinforced concrete column to improve structural integrity. This type of application is particularly beneficial for earthquake prone area. In architectural area FRP can be used in many applications such as cladding, roofing, flooring and partitions. Corrosion is one of the main problems faced by construction industries. The use of durable and lightweight GFRP protects will be very beneficial. Corrosion problem minimizes and maintain the long term maintenance cost of structure will be reduced substantially. As for the structural application where the member will carry loads as pedestrian footbridge can be constructed using GFRP sections. GFRP grating are being used as manhole cover to solve problem of missing steel. GFRP is not recyclable at present hence missing of steel grating can be solved and this will ensure the safety of public. GFRP products were recorded including water tank, pultruted sections, plate's domes, gratting, partitions, ceiling, doors, signboards, pipes and many others. In the earthquake prone countries the use of FRP products can also play an important role in minimizing the damage.

3. LITERATURE REVIEW

Hamid Saadatmanesh, Mohammad R. Ehsani(1991), carried out study on the static strength of reinforced concrete beams strengthened by gluing glass-fiber-reinforced-plastic (GFRP) plates to their tension flanges experimentally. Five rectangular beams and one T-beam were examined to failure under four point bending. The results shows that the flexural strength of RC beams can be significantly increased by gluing GFRP plates to the tension face. In addition, the epoxy bonded plates improved the cracking behaviour of the beams by delaying the formation of visible cracks and reducing crack widths at higher load levels. They also found that the gain in ultimate flexural strength was more significant in beams with lower steel reinforcement ratios.[Ref.11]

Thomas E. Boothby, Junhui Jia, Charles E. Bakis, Tennisha L. Brown (2005), investigated 90-cm-long plain concrete beam specimens reinforced with externally bonded wet-laid glass fiber reinforced-polymer sheets. The specimens were precracked with a three point flexural load, subjected to a constant four point flexural load of about 25% of the initial ultimate moment, and placed into different environmental conditions like indoor laboratory, outdoor, elevated temperature/dry, and freeze/thaw. By varying the exposure time in different environments and using the photoelastic coating method to evaluate strain distributions, the durability of the externally reinforced concrete beams was evaluated. The degradation of bond under combined mechanical and environmental loading was quantified in terms of variations of local bond-slip model parameters. They observed debonding of GFRP sheets from concrete as a dominant failure mode. They also observed that among all of the environments, the longest duration freeze/ thaw and elevated temperature/dry environments cause the most severe degradation of the interfacial fracture energy, peak shear stress, and slip at complete debonding.[Ref.9]

Iman Chitsazan, Mohsen Kobraei, Mohd Zamin Jumaat and Payam Shafigh (2010), As it is known, fiber reinforced polymer (FRP) bars are typically quite different from those of steel bars and they depend mainly on both matrix and fibers type, as well as on their volume fraction; 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. In this research, we have investigated flexural behavior in reinforced concrete beams with glass fiber-reinforced polymer (GFRP) and have analyzed the different kinds of failure, ultimate moment capacity, deflection, load of first crack, how to create and expand cracks, tensile and compressive strains created on beam and position of neutral axis (NA) during loading for different ratios of bars on 10 laboratorial specimens. Using high strength concrete instead of normal concrete and increasing the effective depth over the breadth on flexural behavior of concrete beams with GFRP had been studied. Results taken from the experimental tests have been compared with ACI 440 and they show that deflections, width of cracks and the cracks' extent are further used toward the usual RC beams. High strength concrete instead of normal concrete is the ascended load of the first crack and it created more cracks, but with less width of crack. It is recommended that the selected ratio of effective depth over breadth (d/b) is slightly larger than 2. In addition, it can be said that the amount of the balanced bar provided by ACI 400 is not an exact criteria to determine the type of failure, and it is only in cases where the ratio of bars are lower than the balanced mode that ruptures occur in reinforcement area.[Ref.4]

TarekH.Almusallm, Yousef A.al-salloum (2013), carried out study to investigate the flexural characteristic of RC beams with help of GFRP sheets and strips. Ten simply supported reinforced concrete beams with square cross section of 150 × 150 and a span length of 1000 mm were tested as two of them were tested as a controlled beams. The mode of failure was found flexure zone as load increased higher. These cracks gradually increase in height with an increase in load. Finally they observed that the mode of the failure was characterized by intermediate crack debonding of the bottom FRP for all the strengthened beams. They also found the effect of width of GFRP laminate on debonding mechanism.[Ref.6]

Rathi V.R, Ghogare A.V, Nawale S.R (2014): Paper on "Experimental study on glass fiber reinforced concrete moderate deep beam" The result of glass fiber reinforced moderate deep beam with and without stirrups have been presented. Six tee beams of constant overall span and depth 150mm, 200mm, 250mm, 300mm with span to depth (L/D) ratios of 4,3,2.4, &2 and glass fibers of 12mm cut length and diameter 0.0125mm added at volume fraction of 0%, 0.25%, 0.50%, 0.75% & 1 %.The beams wear tested under two point loads at mid span. The results showed that the addition of glass fiber significantly improved the compressive strength, split tensile strength, flexural strength, shear stress and ductility of reinforced moderate deep beam without stirrups.

Satya M Saad, Indrajit Patel, Nandish Pethani (2014): Carried out study on "Basalt fibre reinforced polymer (BFRP):Effective replacement of steel in reinforced concrete" They come to know that concrete structures are usually reinforced because plain concrete has strong limitations to resist tension. One of the familiar reinforcing material is steel; it suits well as reinforcement but has quite well known pros and cons. Fibre Reinforced Polymer (FRP) have over the past years became an interesting choice as a reinforcement for concrete. There are widely researched range and types of FRP namely: Aramid FRP (AFRP), Carbon FRP (CFRP) and Glass FRP (GFRP). FRP shows various advantages out of which few are: high tensile strength, high strength-weight ratio, no corrosion and also light in weight. These many of such benefits suggest the structural designers to research & implement on a large scale the replacement of steel with different FRPs as a choice of reinforcing material for concrete. One of the choices that we have made is Basalt Fibres Reinforced Polymer (BFRP) which is rather a new material to structural design, although it has been known for several decades. They are made from basalt rock, are very light and have tensile strength, over twice as high as steel. Tensile strength of BFRP tendon is about twice the tensile strength of steel reinforcement and elongation of BFRP tendons is much more than of steel. To utilize the high tensile strength of BFRP and prevent cracking of concrete, the tendons could be prestressed. This paper focuses on the various performance based study of BFRP on reinforced concrete properties where we replaced reinforcing steel with BFRP and extended it as a prestress reinforcement to achieve few specialties in reinforced concrete elements. .

D.N. Shinde, Pudale Yojana M, Nair Veena V (2014), Existing concrete structures may, for a variety of reasons, be found to perform unsatisfactorily. This could manifest itself by poor performance under service loading, in the form of excessive deflections and cracking, or there could be inadequate ultimate strength. Additionally, revisions in structural design and loading codes may render many structures previously thought to be satisfactory, noncompliant with current provisions. In the present economic climate, rehabilitation of damaged concrete structures to meet the more stringent limits on serviceability and ultimate strength of the current codes, and strengthening of existing concrete structures to carry higher permissible loads, seem to be a more attractive alternative to demolishing and rebuilding. This paper investigates the Flexural behavior of R.C.C. beam wrapped with GFRP Glass Fiber Reinforced Polymer) sheet. A total 8 beams, with (150×150) mm rectangular cross section and of span 700 mm were casted and tested. Three main variables namely, strength, ductility and damage level of R.C.C. under reinforced beam and R.C.C. beam weak in flexure were investigated. In first set of four R.C.C. under reinforced beams two were strengthened with GFRP sheet in single layer from tension face which is parallel to beam axis subjected to static loading tested until failure; the remaining two beams were used as a control specimen. In second set of four beams weak in flexure two were strengthened with GFRP sheet tested until failure; the remaining two were used as a control specimen. Comparison has been made between results of two sets.[Ref.3]

Swami P.S, Patil S.S, Kore P.N (2015): Carried out study on "Behavior of concrete deep beams with high strength reinforcement" They state that the high performance reinforcement continues to gain wider acceptance in industry practice, due to improved mechanical properties of new materials. For decades, methods of design and analysis of concrete members reinforced with normal strength steel have been developed. Recently, reinforcing steel (550 & 550) with strength higher than conventional steel has become commercially available. The introduction of high strength reinforcing steel can be useful to reduce the quantity of reinforcement required, thereby lessening reinforcement congestion and improving constructability. This paper presents construction and testing of several high strength reinforced concrete deep beams which includes three beams, designed for three different country codes, for each shear span to depth ratio as described and the test data is presented. The beam consists of simple span subjected to two point loading, each span being 0.7 m in length. The shear span to depth ratios ranged from 0.62 to 0.77. From the data revealed by the analysis, design and experimental work following conclusions are summarized Failure of deep beams was mainly due to diagonal cracking and it was along the lines joining the loading points and supports. The cracks pattern and failure mechanisms for deep beams reinforced with high strength reinforcement were similar to those deep beams with normal strength reinforcing steel. The strength of beams with 250 mm shear span is less than that of 200 mm shear span which means the strength of deep beam is inversely proportional to the shear span for the constant depth of the beam. It is assumed that the arching action of the main tension steel & the web steel together with concrete will carry the shear. All deep beams had low deflection at failure as there was no flexural failure. As reported by F. K. Kong the shear strength of deep beams is 2 to 3 times greater than that given by usual equations. But in this case due to use of high strength reinforcement the shear strength of deep beam is found 6 times greater than design loads.

Keertika Sharma, S. S. Kushwah, Aruna Rawat (2016), Fibre reinforced polymer (FRP) is a composite material consisting of a polymer matrix fortified with fibers. The most frequent types of fiber used in structural applications are glass (GFRP), carbon (CFRP) and aramid (AFRP). The GFRP is the least costly but has lower strength and significantly lower stiffness compared to other alternatives. CFRP is the stiffest, long-lasting, and costlier. AFRP has improved durability and admirable impact resistance. FRP reinforcement is accessible in different forms such as bars, grids, prestressing tendons and laminates to serve a wide range of applications. Earlier the use of FRP was limited to defence and aerospace engineering due to its high cost, but enhance in demand for the consumption of FRP in other fields around the world has aided the growth in research for better performance of composites at low costs. The reinforcement has high durability and stiffness while the matrix binds the fibres together, allowing stress to be relocated from one fibre to another and producing a consolidated structure. In the last some years, FRP materials have emerged as capable alternative refurbish materials for reinforced concrete (RC) structures. FRP plates or sheets can be bonded to the outer surface of concrete structures using high strength adhesives which increases the tensile strength of the member. The present study focuses on using CFRP, GFRP and AFRP bars as an internal reinforcing material for RC beams.[Ref.5]

4. OBJECTIVES

- To study the flexural behavior of reinforced concrete beams.
- To study the effect of GFRP strengthening on ultimate load carrying capacity and failure pattern of reinforced concrete beams.
- To study the shear behavior of reinforced concrete beams.
- To study the effect of GFRP strengthening on the shear behavior of reinforced concrete beams.

4. METHODOLOGY

The purpose of this research is to investigate the flexural and shear behavior of reinforced concrete beams strengthened with varying configuration and layers of GFRP sheets. More particularly, the effect of the number of GFRP layers and its orientation on the strength and ductility of beams are investigated. Two sets of beams were fabricated and tested up to failure. In SET I three beams weak in flexure were casted, out of which one is controlled beam and other two beams were strengthened using continuous glass fiber reinforced polymer (GFRP) sheets in flexure. In SET II three beams weak in shear were casted, out of which one is the controlled beam and other two beams were strengthened by using continuous glass fiber reinforced polymer (GFRP) sheets in shear.

5. CONCLUSION

It is expected that effective procedure of wrapping beam enhances the strength in flexure & shear including the change of failure mode as well as change the location of failure plane.

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BIOGRAPHIES

She is a PG student with intend in Reasearch work.

He is an excellent academic person and PG student preciesely Working on number of research projects which is related with strucutral engineering.

He is Research scholor having more than 31 years teaching experience. Published number of reasearch paper, guided number of research project and PG,UG student.