STRENGTHENING OF STEEL FIBER REINFORCED BEAMS USING GFRP

Shivani Bhardwaj[1], Mandeep Kaur[2]

[1] Assistant Professor in Sri Sai College of Engineering and Technology , Badhani-pathankot, Punjab
[2]Head of Department in Lovely Professional University, Punjab, India.

Abstract:- *Fiber Reinforced Polymer application is one of the effective way to repair and strengthen structures that have gone structurally weak over their life span. Experimental investigations on the flexural and shear behavior of concrete beams strengthened using continuous glass fiber reinforced (GFRP) sheets tested to failure using a symmetrical point concentrated static loading system is done in this research. Experimental data on load, deflection and failure mode of each beam is to be obtained. In the present experiment the strengthening of steel fiber reinforced beams wrapping with glass fibers reinforced polymer is studied. 1% of steel fiber is used in each beam. Total five beams were cast out of which one is control beam and four beams using steel fibers with M25 grade of concrete in the experiment and the wrapping of GFRP will be on four different orientations. There is an effective increase in the strength of the concrete after using fibers in it. As a structure can deteriorates easily after a long use so as to reduce the deterioration of the structure we use steel fibers and for the strengthening of structure we use glass fiber reinforced polymers. The main aim of the study is to find out the maximum strength of the concrete using steel fibers using GFRP wrapping.*

Keywords:-**Steel Fibers, GFRP, FRP**

1. INTRODUCTION

Maintaining the size of structural element on increasing the load, is the most commonly emerging issue in civil engineering. In the structures the additional strength for the structures may be required for the allotment for higher loads to be placed. The additional strength for the structures is needed when structure's use is changed and to decrease the lack of higher level of load carrying capacity of the structures. This occurs when additional mechanical apparatus, filling systems, planters, or other item snare being added to a structure for the industrial and mechanical use. The large amount of structural strengthening involves improvement capacity of the structural element to resist the listed external forces caused by loading: flexure, shear, axial, and torsion. Most commonly used strengthening techniques such as section enlargement, externally bonded reinforcement, post-tensioning, and supplemental supports may be used to achieve improved strength and serviceability.

1.1 FIBER REINFORCED CONCRETE:

Fiber Reinforced Concrete are defined as a material which is a composite mixture of cement, concrete and discontinuous, discrete, uniformly distributed suitable fibers. Fiber is expressed as a tiny part of reinforcing material which are having certain characteristics properties. The shape of fibers may be round or straight. Aspect ratio is one of the main criteria which elaborate the fibers easily. The aspect ratio of the fiber is said to be the ratio of its length to its diameter. Most of time the aspect ratio ranges from 30 to 150mm.It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities. Concrete reinforced with fibers is less expensive than hand-tied rebar, while it increases the tensile strength many times. These are most commonly used in the aircrafts, automotive, naval, and construction industries. Fiber-reinforced polymer is an advanced material for strengthening of RC and masonry structure and mostly development in its application in structural retrofitting has taken place in the last two decades. It is observed that this is are placement of steel plate bonding which is very much effective in strengthening of columns by exterior wrapping. The merit of FRP is that it is having high strength to weight ratio and it is highly corrosion resistance material.

2. LITERATURE REVIEW

S.M. Homan et.al (2000) in this study on the durability of FRP is used in concrete structures. It is taken FRP materials to be studied for their durability and also the FRP-reinforced concrete was investigated. Noticeable effect on the properties of bonding is occurred only in freeze thaw and moisture exposes. They conclude that the specimen which are exposed were tested at direct tension and also to direct shear to find out the effects of environmental conditions of the long term performance of FRP.

Francesco Micella et.al (2004) has done a research on strength of FRP bars for concrete buildings. In this study they make an experimental observation to found the effects of FRP rods. The parameters taken are freeze thaw, high relative humidity, high temperatures etc. they have done some mechanical and some physics tests too to check the properties and analyze the causes which damage and reduce the strength. According to this research the resin properties of the materials

may influence the durability of FRP. From the experiment they have concluded that there is decrease in the apparent shear strength of around 30% for specimens selected for the test and for specimens while they are tested the results and are decreases in 20% of strength. They have also done the electronic microscopy so that they can analyses the mechanical damage to the specimen caused by the aggressive agents.

Azadeh Pzrvin et.al (2014) has done a research on FRP composite strengthening of the concrete columns under various loading conditions. This study deals with the areas in which the FRP strengthening of columns are taken into consideration for several loadings. In this they have considered the addition of these FRP materials to modify or to increase the strength of structure and it can help to reduce the damaging effect to infrastructure and also to prevent the costly replacement. From this they have studied that with the use of those FRP materials they can restore as modify the column original design strength for the possible axial acting, shear as flexural and also help in some structure to carry maximum load than that for which they are constructed. They have concluded that as the shape of the columns is modified from square column to circular and from rectangular to elliptical column will help to eliminate the stresses at corners and improve performance as FRP–wrapping of different shade modified columns. Will help to increase the axial load and ductility. As the use of FRP the strengthening of the column get measured. As the column is repaired with the FRP for corrosion of columns improves the strength but also help to decelerate the speed of corrosion.

Dr. V.P. Joshi et.al (2014) has done research on the applications and properties of fiber reinforced concrete. In this they considered that micro-cracks start developing in structure before loading because of drying shrinkage and other causes of change in volume. So they used FRP which having small fibers in it. Which are distributed randomly in the mixture of concrete when it is prepared and hence it increases the properties of concrete in every direction. These can help to transfer the load acting on them to the internal micro cracks. This FRP is recently developed and this used in construction showing excellent flexural–tensile strength , resistant to splitting also to impact resistance properties it is the most effective way in which they can increase the toughness and also the resistance to plastic shrinkage of master is improved. Steel fibers used can also help to reduce the heavy steel reinforcement requirement. Durability of the concrete is also improved with the reduction in the width of cracks. Many developments are made so far. Some of conclusions from the experiment is found out that there is improvement in compressive strength and also the tensile strength is improved and also the flexural strength is improved by 3 times more as they compared to the conventional concrete.

3. MATERIAL

AGGREGATES

Crushed Coarse aggregates of 20mm and 10mm were used in the investigation with specific gravity of course aggregates is 2.64 and fineness modulus is 6.80.

CEMENT

OPC of 43 grade is basically used for the investigation. Mostly the tests were performed in Procedures described in IS: 8112-2003.Cement is a adhesive in nature, a material that hardened and can be used to bind other material with each other. Cement is usually grey powder before being mixed with other materials and water.

GLASS FIBER

Glass fiber is composite consisting of glass fibers either continuous or discontinuous contained within a polymer matrix, this type of composite is produced in largest quantities .composition of glass that is mostly commonly drawn into fibers. Fiber diameter normally ranges between 3 and 20 m.

STEEL FIBERS

Steel fibers are long filament with diameter generally in order of 10mm.the aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. Steel fibers used in present investigation were Novocon XR-1050, which is one of the leading low carbon steel wire fiber. It is evenly distributed to concrete mixtures to provide improved mechanical bonding capacity and to enhance the shear strength and flexural strength of concrete.

Table -1: PROPERTIES OF STEEL FIBERS

Sr.No.	Character	Value
1	Length	50mm
2	Diameter	1.0 mm

3	Shape	Continuously deformed
4	Tensile strength	800N/mm^2

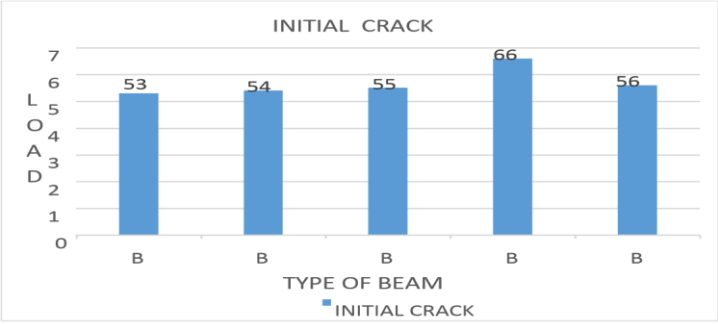
4. METHODOLOGY

In this control beam is cast to check the cracking behaviour of the beam. After this beams with 1% volume of beam of steel fiber is wrapped with GFRP at four different orientations were cast. For testing of beams two point loading arrangement was used in CTM and different results are noted and found that which arrangement is suitable for the strengthening of beams and which arrangement can carry ultimate load.

In the present research work mainly two materials are used namely steel fiber and GFRP .GFRP was available easily in the form of mat and steel fiber was taken from industry in delhi. In this work first of all 5 beams were cast .one of them is was without steel fibers and GFRP wrapping and other four were cast with steel reinforcement and GFRP wrapped on their different orientations. All the beams were tested under two point loading frames in lab of institutes. The testing procedure was same for all specimens. In this experiment after casting beams they are cured for 28 days and they are taken out from water and washed away and its surface was cleaned for the clear visibility of irregularities. Two point loading arrangement was used for testing of beam.

5. RESULTS AND DISCUSSIONS

- Results of beams wrapped with GFRP at four different orientations. The behavior of these beams throughout the testing upto failure is described and ultimate load and crack patterns and modes of failures of each beam.
- Flexural and shear strength of section is depended on controlling failure modes. The flexural and shear crack observed while testing of strengthened beams sections. Failure of beams like:
- Firstly crushing of concrete occurs in compression before the yielding of reinforcement.
- After that rupture of GFRP laminates occurs and then yielding of steel.
- Shear and flexure cracks occurs at different positions.
- Debonding of FRP laminates from concrete surface.



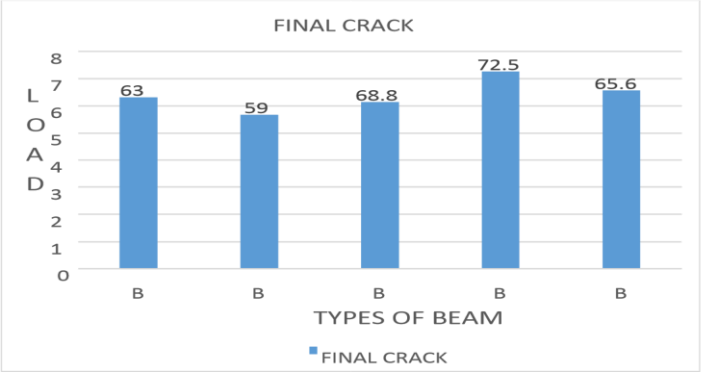


Table -2: TEST RESULTS

Sr. no.	Beam type	Initial crack (in KN)	Final crack (in KN)	Failure pattern
1	Control beam	53	63	Shear and flexure crack
2	GFRP at three sides	54	59	Shear crack
3	GFRP at sides with bottom	55	68.8	Flexure crack
4	GFRP at sides only	66	72.5	Flexure crack
5	GFRP at middle	56	65.6	Shear crack

6. CONCLUSIONS

- The initial crack appears in the beam B2 which is wrapped at three faces of the beam at load 55 which is greater than the load for control beam B1 . The final crack occurs at the load value of 68.8 which is also grater that the value of load for control beam at final crack.
- Initial crack is further increased by strengthening the beam at sides and the soffit of the beam as well as middle of the beam. The ultimate load carrying capacity of beam B3 and B5 is 55 and 56 which is greater than control beam.
- The load carrying capacity of beam B4 which is • Amir, M., Patel, K. (2002).“Flexural strengthened at sides of the beam is greater than strengthening of reinforced concrete flanged the load carrying capacity of the control beam. Beams with composite laminates”, Journal of This beam is having 10% more value of load than Composites for Construction, 6(2), 97-103. The control beam and 4% greater than B2.It is also 7% greater than the beam B5.
- The bonding between GFRP sheet and the concrete is intact up to the failure of the beam which clearly indicates the composite action due to GFRP sheet.
- The beam B3 which is wrapped at the sides is having maximum load carrying capacity and after cost analysis it is concluded that if the sheet is wrapped at the sides it will be less costly than the other samples.

7. REFERENCES

1) Aiello, M.A. and Ombres, L. (2000). “Loaddeflection analysis of FRP reinforced concrete flexural members” Journal of Composites for Constructions, ASCE, 4 (4), pp. 164-173.

2) Woodward, R. and Duffy, N, 2011. Cement and concrete flow analysis in a rapidly expanding economy: Ireland as a case study. Resources, Conservation and Recycling, Vol. 55, pp. 448-455.

3) Banthia N (2012), FRC: “Milestone in international Research and development”, proceeding of FIBCON2012, ICI, Nagpur, India, February 13-14, pp 48 [S]

4) Nataraja M.C., Dhang N. and Gupta A.P, (1998), “Steel Fiber Reinforced Concrete under compression”, The Indian Concrete Journal, 26[3], pp 353-356.

5) Senne, J., Fatigue life of Hybrid FRP Composite Beams, in Engineering Science and Mechanics.2000, Virginia Tech: Blacksburg.

6) Ameli, M. and Ronagh, H.R. (2007). “Behavior of FRP strengthened reinforced concrete beams under torsion”,Journal of Composites for Construction, 11(2), 192-200.