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Strength Characteristics of Concrete Specimen Wrapped With Glass Fiber Reinforced Polymer

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Abstract: Glass Fiber Reinforced Polymer (GFRP) is one of a relatively new class of composite material. These materials are manufactured from a combination of fibers and resins. These composite materials have proven to be efficient and economical for the development of new structures and the repair of deteriorating structures in civil engineering. One of the important reasons for the use of GFRP composite materials is because of its superior mechanical properties. These mechanical properties includes impact resistance, strength, stiffness, flexibility and also its enhanced ability to carry loads. In construction industry, in order to meet the advanced infrastructure requirements, new innovative technologies and materials are being introduced. Also any new technology or material has its own limitations but to meet the new requirements, new technologies and materials have to be invented and put to use. With structures becoming old and increasing bar corrosion, old buildings have to be retrofitted with additional materials to increase their durability and life. For strengthening and retrofitting of concrete structures confinement with FRP has various applications. In this project concrete specimens are wrapped with glass fibre reinforced polymers to study the effect of confinement in the strength of specimens. For wrapping bi-directional and uni-directional glass fibre reinforced polymer mats are used. During the uni-directional glass fibre reinforced polymer wrapping, it is wrapped in both horizontal and vertical directions. The fiber used in this paper is bi-directional fibre. To find the effect of wrapping, specimens are wrapped in one rotation and two rotations.

Keywords: Glass Fiber Reinforced Polymer, composite, confinement, wrapped.

I . INTRODUCTION

In construction industry, in order to meet the advanced infrastructure requirements, new innovative technologies and materials are being introduced. Also any new technology or material has its own limitations but to meet the new requirements, new technologies and materials have to be invented and put to use. With structures becoming old and increasing bar corrosion, old buildings have to be retrofitted with additional materials to increase their durability and life. FRP for confinement is an excellent tool for effective retrofitting and strengthening application. One of the early applications of confinement in FRP is its application in seismically active areas. But confinement also has a lot of applications in non-seismic zones too. For example they are used in areas where explosive attacks are possible such as bomb blasts. Also they are used if the load carrying capacity of a column has to be increased because of additional weight due to the addition of new storey to the existing building or if an existing bridge deck has to be widened. In any of the above cases, the confinement with FRP may be done by either prefabricated jackets or by in situ cured sheets. Epoxy is used as an adhesive to bond the FRP composites in the tension zone of beams, columns or plates to increase their flexural strength. The fibers must be applied in direction parallel to high tensile stresses. Hence, FRP composites are finding ways to prove effective and economical at the same time.

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II MATERIALS

A. Cement

Ordinary Portland cement of 43 grade is used. The specific gravity was found as 3.15 after using the pycnometer test and was found to be within the limit specified by the IS code. The initial setting time and final setting time were 22 minutes and 250 minutes respectively.

B. Fine aggregate

The fine aggregate used in the experiment is normal locally available sand , it is in zone II.
Having a specific gravity 2.64
Water absorption 1%
Fineness modulus 2.46
All the properties are found to be within the limit specified by the IS code 383:1970.

C. Coarse aggregate

The coarse aggregate used in the experiment consists of crushed or broken stone of which 95% is retained on 4.75mm IS sieve.
Having specific gravity 2.70
Water absorption 0.5%
Impact value 16.92%
These properties are also found to be within the limit specified by the IS code 383:1970.

D. Glass fiber reinforced polymer

The components of glass fiber reinforced polymer are given below

1. *Epoxy*

One of the important components of the GFRP is the epoxy resin. Epoxy has many functions; one of them is to transfer the stress between the fibers that are used as reinforcements.

The other function is to act as a glue to hold the fibers together and protect the fibers from mechanical and environmental damage.

2. *Reinforcements*

Fibers are mainly used for carrying the load along the length of the fiber to provide strength and stiffness in one direction. Reinforcements can be adapted to provide tailored properties in the direction of the loads applied on the end product. The largest volume reinforcement is glass fiber.

3. *Fillers*

The main function of a filler is to improve the performance of the composite material, also in some cases these are also used to reduce the cost of the composite. The resin is normally expensive, so by adding the filler with resin the cost is significantly reduced. The fillers also have benefits such as shrinkage control and crack resistance and also it provides smooth surface which helps during the application of resin.

4. *Additives*

Additives and other modifier ingredients are used to increase the usefulness of polymers and extend product durability.

Fig 1:glass fiber mat and epoxy resin

E. Water

The water used for mixing is portable drinking water which has a pH value of 7 and it was conforming to IS 456-2000. The same type of water is also used for curing of specimens.

III WRAPPING OF SPECIMEN

A. Grinding and surface preparation

For wrapping of specimens, first it is necessary to make the surface as smooth as possible. Confinement of specimen is only effective if the specimen is properly wrapped. For round columns, it is possible if the surface is smooth but for square columns, all the sharp corners must be grinded to form a minimum of 20mm radius for improving the effectiveness of confinement and also grind the plane surface for smooth operation. Even if the surface is uneven, putty is applied to get a smooth surface

Fig.2 specimens prepared for wrapping

B. Epoxy coating and wrapping of fiber

First the surface is coated with a primer, after that it is ready for application of epoxy. For wrapping the fiber there are two techniques employed. They are

1. First the two-component adhesive is mixed properly in required proportion. Then the adhesive is applied immediately on the surface of the specimen where the fiber is to be placed. Soon the fiber is wrapped around the specimen. After that a second coat of adhesive or in this case epoxy is applied.

Fig.3 Applying of fiber sheet

2. The second method consist of a wet layup machine which is used to pre wet the fiber and then apply it to the surface of specimen .To ensure smooth functioning of fiber wrap, air bubbles if present must be removed by using a roller by rolling over the trapped air bubbles.

Fig.4 specimens after wrapping

IV EXPERIMENTAL WORK

A. Test on fresh concrete

To determination of the workability of concrete the various test was used such as, Flow table test, Slump test.

1.Slump Test

The consistency and workability of the fresh concrete is measured by using slump test. The slump cone used is according to the specification of IS 7320:1970. True slump is achieved with the fresh concrete.

B. Mix Proportion

For M30 grade concrete, the mix proportion will be

Water	Cement	Fine aggregate	Coarse aggregate
186 lit	485	512	1241
0.38	1	1.05	2.54

For M35 grade concrete the mix proportion will be

Water	Cement	Fine aggregate	Coarse aggregate
191.5 lit	563.47	479.1	1155.32
0.34	1	0.85	2.05

For M40 grade concrete the mix proportion will be

Water	Cement	Fine aggregate	Coarse aggregate
180 lit	545.45	404.1	1323.5
0.33	1	0.75	2.4

C. Test on hard concrete

1. Compressive Strength Test

For the sake of comparison, we have casted specimen for three grades of concrete M30, M35 and M40. For finding the compressive strength, specimens of size 150x150x150 are casted individually for these three grades of concrete. For each grade of concrete three numbers of specimens are casted. A table vibrator is used to vibrate the specimen. Then the specimen is left for 24 hours. After that they are demoulded and taken to the curing tank, where they are allowed to cure. After 28 days of curing each specimen is wrapped using glass fiber reinforced polymer. Then the wrapped specimen are kept undisturbed for two days. Then they are tested on compression testing machine. The load at which the cube fails is noted for each specimen and the average value is noted. Then using the compressive strength formula, compressive strength of the cube specimen is found out for each grade.

Compressive strength (MPa) = load at failure / cross sectional area.

Fig 5: compression test taken for cube

2. Split Tensile Strength

For testing the Split tensile strength ,we have casted the cylinder specimen of diameter 150 mm and height 300 mm . After vibrating, the specimens are kept undisturbed for 24 hours, after that they are demoulded and taken to the curing tank. At the curing tank, they are cured for 28 days. Then they are taken out and dried. Then they are wrapped using glass fiber reinforced polymer. After wrapping they are kept undisturbed for 2 days for drying. Then they are tested under compression testing machine. Three cylinders in each category were tested and their average value of each grade is found out. The following formula is used for finding the split tensile strength

Split Tensile strength (MPa) = 2xP / πx dxL,

Where, P = load at failure,

d = cylinder diameter,

L = cylinder length

Fig 6: Split Tensile Test on cylinders

3. Flexural Strength Test

For finding the flexural strength, we have casted three number of beam specimens for each grades of size 150x100x1000 mm. After vibrating, they are kept undisturbed for 24 hours for setting then they are demoulded and are taken to the curing tank and they are cured for 28 days. Then they are wrapped using glass fiber reinforced polymer. The flexural strength specimens are tested under two point loading, over an effective span of 600 mm on a loading frame. Failure loads and their corresponding deflections were found out for each specimen. After that the flexural strength is calculated using the following formula

Flexural strength (MPa) = (PxL) / (bxdx2),

Where, P = Failure load,

L = distance between the support = 600 mm,

b = specimen width=100 mm,

d = specimen depth = 150 mm.

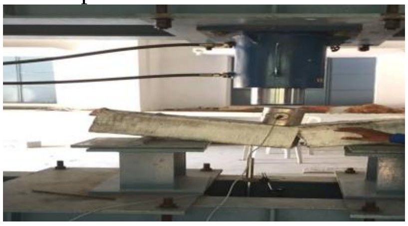

Fig 7: flexural strength test for beam

V RESULTS AND DISCUSSION

After 28 days curing specimens are wrapped with 1.2 mm thick glass fibre mat by using epoxy polymers. Specimens are tested after 7 days of wrapping. The fiber that is used in this paper is a bi-directional one. To find out the effect of wrapping, the specimens are wrapped in both single and double rotation. One set of beams, cubes and cylinders are tested without wrapping, another set is tested with single rotation wrapping and another set is tested with double rotation wrapping.

A. Wrapped with bi-directional mat

1. Compressive strength of concrete cubes (for 28 days)

Types of specimen	M30	M35	M40
Unwrapped specimens	29.92	34.45	39.87
Wrapped with GFRP mat(single rotation)	44.88	51.67	59.8

Wrapped with GFRP mat(double rotation)	50.86	58.56	67.78

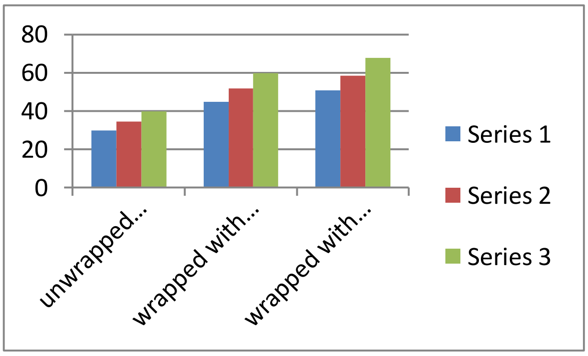

Fig 8: compressive strength of concrete

2. Split tensile strength of concrete cylinders (for 28 days)

Types of specimen	M30	M35	M40
Unwrapped specimens	3.15	4.12	5.64
Wrapped with GFRP mat(single rotation)	4.72	6.18	8.46
Wrapped with GFRP mat(double rotation)	5.35	7	9.58

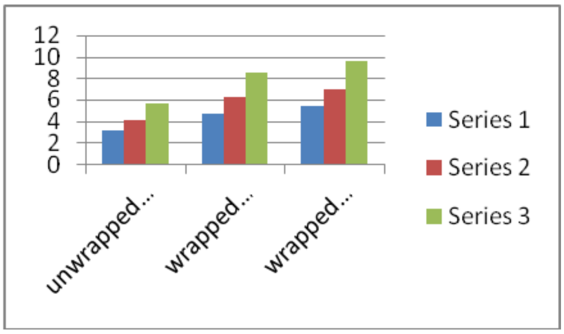

Fig 9: split tensile strength of concrete

3. Flexural strength of beam (for 28 days)

Types of specimen	**M30**	**M35**	**M40**
Unwrapped specimens	**4.2**	**5.32**	**6.42**
Wrapped with GFRP mat(single rotation)	**6.09**	**7.82**	**9.63**
Wrapped with GFRP mat(double rotation)	**7.1**	**9.04**	**10.91**

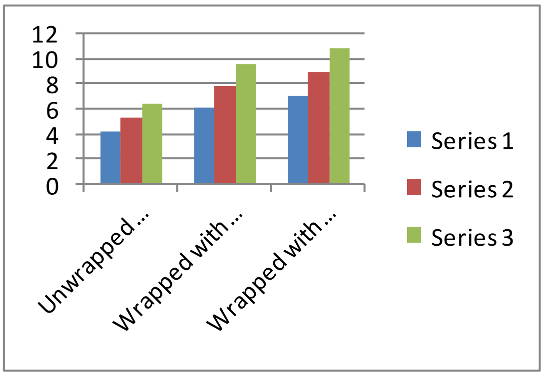

Fig 10: flexural strength of concrete

VI CONCLUSION AND FUTURE WORK

In construction worldwide, the use of FRP is very ideal because of its mechanical properties. For retrofitting and strengthening applications the confinement using FRP is very effective. One of the early applications of FRP materials in infrastructure is confinement in earthquake prone areas. But confinement also has a lot of applications in non-seismic zones too. For example they are used in areas where explosive attacks are possible such as bomb blasts. Also they are used if the load carrying capacity of a column has to be increased because of additional weight due to the addition of new storey to the existing building or if an existing bridge deck has to be widened. In all the above cases, confinement with GFRP is provided by wrapping Reinforced concrete columns with in situ cured sheets, in which the direction of principal fiber is in circumferential direction. Strengthening of other structural elements such as beams, Plates and columns are also possible through the use of FRP composites by bonding it to their tension zone using epoxy as an adhesive. Strength of concrete members confined with GFRP mat is improved by 1.7 times than the strength of unwrapped specimens. For the future work, the GFRP wrapped specimen can be checked for various atmospheric conditions such as high temperature and under water conditions etc .If the underwater conditions are successful; it can be used for repairing and retrofitting the old bridges.

REFERENCE

1. Ahmed Khalifa, William J.Gold, Antonio Nanni and Abdel Aziz (1998) “Contribution of Externally Bonded FRP to Shear Capacity of RC Flexural Members” Journal of Composites for Construction, Vol. 2, No. 4
2. Akhrawat Lenwari, Thaksin Thepchatri and Pedro Albrecht (2006) “Debonding Strength of Steel Beams Strengthened with CFRP Plates” Journal of Composites for Construction, Vol. 10, No. 1
3. Alex Li,ules Assih and Yves Delmas (2001), “Shear Strengthening of RC Beams with Externally Bonded CFRP Sheets” Journal of Structural Engineering, Vol. 127, No. 4
4. Anders Carolin and Bjorn Täljsten (2005) “Experimental Study of Strengthening for Increased Shear Bearing Capacity” Journal of Composites for Construction, Vol. 9, No. 6, Dec
5. Bimal Babu Adhikary and Hiroshi Mutsuyoshi (2004)“Behavior of Concrete Beams Strengthened in Shear with Carbon-Fiber Sheets” Journal of Composites for Construction, Vol. 8, No. 3.
6. Cao S.Y, Chen J.F., Teng J.G., Hao Z, Chen J.,(2005)“ Debonding in RC Beams Shear Strengthened with Complete FRP Wraps” Journal of Composites for Construction, Vol. 9, No.5.

7. Carlo Pellegrino and Claudio Modena, (2002) "Fiber Reinforced Polymer Shear Strengthening of Reinforced Concrete Beams with Transverse Steel Reinforcement" Journal of Composites for Construction, Vol. 6, No.2.
8. Chaallal O., M.J.Nollet and D.Perraton,(1998) "Shear Strengthening Of Rc Beams By Externally Bonded Side CFRP Strips'' Journal Of Composites For Construction, Vol.2,No.2,pp. 111-113.
9. Chan T.K.,Cheong H.K. and Nguyen D.M .(2001) "Experimental Investigation on Delamation Failure of CFRP Strengthened Beams'' International Conference on Advanced Technologies In Design,Construction And Maintenance of Concrete Structures, pp.1-7.
10. Chen J.F and Teng J.G.,(2001) "Anchorage Strength Models For FRP And Steel Plates Bonded To Concrete'' Journal of Structural Engineering, Vol.127,No.7,Pp.784-791.
11. Ghani Razaqpur A.,Burkan O.Isgor,Greenaway.S and Alistair Selley (2004) "Concrete Contribution To The Shear Resistance of Fiber Reinforced Polymer Reinforced Concrete Members'' Journal of Composites For Construction, Vol.8, No.5, pp. 452-460.
12. Huy Binh Pham and Riadh Al Mahaidi, (2006) "Prediction of Models For Debonding Failure Loads of Carbon Fiber Reinforced Polymer Retrofitted Reinforced Concrete Beams'' Journal of Composites For Construction, Vol.10, No.1, Pp. 48-59

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C.S.Johnbennet completed the bachelor of engineering degree in civil engineering in Narayanaguru college of engineering in 2015. He also completed the master of engineering degree in structural engineering in Narayanaguru college of engineering in 2017. He presented a paper titled 'SKYBUS' in the International Conference on Global Trends-ICOGT'16 in Immanuel Arasar JJ college of engineering in 2016. Also presented a paper titled, 'Experimental Study on concrete specimen wrapped with glass fiber reinforced polymer' in the International Conference on Recent Innovations in Science Engineering and Technology-ICRISET'17 in Immanuel Arasar JJ college of engineering in 2017. He worked as an assistant professor in James college of engineering and technology from Feb. 2018 to may 2019. Currently he is working as an assistant professor at Narayanaguru college of engineering from july 2019 to till date. He is a member of Institute for Engineering Research and Publication.

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