FLEXURAL BEHAVIOUR OF REINFORCED CONCRETE BEAMS USING GLASS FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT:

Fibre reinforced polymer material systems composed of fiber embedded in a polymeric matrix, exhibit several properties which create the opportunity for their use as structural reinforcing elements. They are characterized by excellent tensile strength in the direction of the fibers. FRP composites do not exhibit yielding, but instead are elastic up to failure. They are also characterized by relatively low modulus of elasticity in tension and low compressive properties. In this study, bidirectional glass reinforced polymer laminate are using for practical approach. After a curing time of 2-3 days, the rehabilitated specimens will be tested until failure. The cracking pattern, ultimate loads and deflected shape of the specimens to be notified The tests will be carried out on ten simply supported reinforced concrete beams with square cross section of 150 150 and a span length of 1000 mm. The beams were strengthened with external U wraps bonded to tension side. The continuous GFRP reinforcement which give delay in de-bonding of bottom longitudinal GFRP laminates. The most investigating parameter in this experimental study is to determine increase in load carrying capacity of strengthened beam. To evaluate the strength of damaged RC beams with externally bonded GFRP laminates was the target of this project. Further the attaining inputs will analyze by using STAD-PRO for optimization.*

Keywords: *Flexural Behaviour, Compressive Strength Split Tensile Strength, Glass Fiber Mix, STADD PRO software Stiffness and Strength*

1.0 INTRODUCTION

Deterioration and aging of concrete structures are not the only reasons for strengthening beams. Other reasons include upgrading design standards, committing mistakes in de- sign or construction, exposure to unpredicted loads such as truck hits or powerful earthquakes, and changing the usage of the structure. Moreover, the ever-increasing truck loads are sometimes beyond the design loads of most bridges in North America that were built after World War II. Since then, the average service loads were increased by 40 percent The strength ening should ideally minimize the amount of material added to the structure to avoid increasing the dead load or decreasing the clearance requirements. Along with that, strengthening should minimize disruption to the structure and its usage. Bonding steel plates might be considered as a very convenient method for strengthening indoor beams. However, the main disadvantage of using steel plates for outdoor applications is corrosion of steel. This corrosion is serious not because it reduces the plates' strength, but because it destroys the bonding between the plates and the epoxy. Concrete is a rigid material with high compressive strength and weak in tensile strength. Reinforcing bars are used to improve the tensile strength. In addition to that fibers can make the concrete more homogenous and can improve the tensile response, particularly the ductility. The various types of fibers added to concrete are steel, glass, carbon, hemp. Fiber reinforced polymer composite materials have been successfully used in the construction of new structures and in rehabilitation of existing structures. Repair with externally bonded FRP reinforcement is a highly practical strengthening system, because of ease and speed of installation, efficiency of structural repair. Bonding of FRP to concrete is faster and less labor intensive. Reinforced concrete structures are exposed to harsh environments yet is often expected to last with little or no repair or maintenance for long periods of time (often 100 years or more). To do this, a durable structure needs to be produced. For reinforced concrete bridges, one of the major forms of environmental attack is chloride ingress, which leads to corrosion of the reinforcing steel and a subsequent reduction in the strength, serviceability and aesthetics of the structure. This may lead to early repair or premature replacement of the structure. A common method of preventing such deterioration is to prevent chlorides from penetrating the structure to the level of the reinforcing steel bar by using relatively impenetrable concrete. The ability of chloride ions to penetrate the concrete must then be known for design as well as quality control purposes. The penetration of the concrete by chloride ions, however, is a slow process. It cannot be determined directly in a time frame that would be useful as a quality control measure.

OBJECTIVES:

To study the behavior of the reinforced concrete (RC) beams reinforced with Glass Fiber Reinforced Polymer sheets at different sides.

- To understand the failure modes of strengthened and non-strengthened beams
- To evaluate the effect of Glass Fiber Reinforced Polymer sheets on the strength and deflection of the strengthened and non-strengthened beams.

2.0 LITERATURE REVIEW

Bush and Brooks [1] evaluated five different reinforcement types including fiber-glass grid on an experiment of a flexible pavement that suffered from transverse cracking. Only strip application of the interlayer was evaluated in this study by placing it on top of the existing cracks. A 50 mm overlay was then placed over the treated sections. Performance was monitored annually using visual surveys for the period from 1999 to 2007. Results of this study showed that fiber-glass grid was the interlayer that performed the best, helping to retard the severity of cracks It has to be underlined that many other related studies on full scale pavements have been realized, not including private research work by manufacturers or transportation agencies that has not been officially published. In general, full scale and field evaluations showed that, in case of properly installed glass fiber grids, with appropriate properties, reinforcement can help to retard reflective cracking. However, no significant improvement in terms of rutting or deflection directly due to the use of glass fiber grid compared to unreinforced solutions has been demonstrated.

Darling and Woolstencroft [2] evaluated the performance of glass grids for retarding reflective cracking through monitoring of two test sites. Both evaluation sites, originally constructed by means of full depth flexible and composite pavements, exhibited severe transverse and longitudinal cracking. A standard glass grid was installed over the full width of the pavement in both sites while a heavy grid was used at three major intersections on construction joints on the first site. Prior to rehabilitation, milling of 50 to 100mm of the existing HMA and repairing of the most severe cracks and patches were realized. The glass grids were then placed between two lifts of asphalt overlay. After four years of monitoring, on both sites, the glass grid reinforced sections performed very well with less reflective cracking compared to the control sections.

K Devendra et al. [3] made an investigation on varying concentrations of fly ash, aluminum oxide, magnesium hydroxide and hematite powder on mechanical properties of E-glass fiber reinforced epoxy composites. The effect of these fillers on ultimate tensile strength, hardness and impact strength were studied. The test results showed that 10% magnesium hydroxide filled composite showed maximum ultimate tensile strength of 375.36 Mpa. Increase in addition of fillers tends to decrease the ultimate tensile strength. From the experimental results it was found that sample with 10% fly ash showed better impact properties compared to other fillers. As the percentage of hematite powder was increased the impact strength increases. Maximum hardness number is obtained for magnesium hydroxide filled composites of 88.69

BHN. Increase in addition of aluminum oxide and hematite increased the hardness but increase in addition of fly ash reduced the hardness of composite

K Naresh Kumar et al. [4] studied the effect of addition of coal ash in the glass fiber reinforced polymer composites. The particle size of coal ash is 52 to 75 The hand layup technique is used for making specimen containing 0%, 4%, 8%, 12%, 16% and 20% weight percentage of coal ash. The tensile, flexural, compression and impact properties are studied according to ASTM standards. Experimentally it was found that 20% ash reinforced polymer composite is having better tensile strength, 16% ash reinforced composite is having better flexural strength and 12% ash reinforced composite is having better compression strength as compared to others. But better impact strength is observed for composites having no ash and there is no significant effect as such on impact properties by addition of fly ash.

K. Martha, B. Nayak, R. K. Mohanta, [4] Concrete is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Plain concrete has two deficiencies, low tensile strength and a low strain at fracture. These shortcomings are generally overcome by reinforcing concrete. Normally reinforcement consists of continuous deformed steel bars or pre-stressing tendons. The advantage of reinforcing and pre-stressing technology utilizing steel reinforcement as high tensile steel wires have helped in overcoming the incapacity of concrete in tension but the ductility magnitude of compressive strength. Fiber reinforced concrete (FRC) is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibers FRC is a relatively new material. This is a composite material consisting of a matrix containing a random distribution or dispersion of small fibers, either natural or artificial, having a high tensile strength. Due to the presence of these uniformly dispersed fibers, the cracking strength of concrete is increased and the fibers acting as crack arresters. Fibers suitable of reinforcing concrete having been produced from steel, glass and organic polymer

METHODOLOGY

Experimental investigations on the behavior of reinforced concrete beams strengthened by using Carbon Fiber Reinforced Polymer (CFRP) in flexural case have been presented in this paper. The experimental work consisted of tested beams. This study took into account strengthened and repaired cases in using Carbon Fiber Reinforced Polymer (CFRP); therefore, similar beams were used for strengthening at one time and for repairing at another time to make a comparison between them. All the reinforced concrete (R.C) beams had been tested in a simply supported span and subjected to two-point loading until the failure. The beams included additional anchorage at the ends of the main Carbon Fiber Reinforced Polymer (CFRP) sheet reinforcement to prevent the delamination of Carbon Fiber Reinforced Polymer (CFRP) sheet. The results of experiments show that the use of Carbon Fiber Reinforced Polymer (CFRP) as external strengthening has significant enhancement on the ultimate load, crack pattern and deflection of the strengthened of beams. It is observed from the work that the use of external Carbon Fiber Reinforced Polymer (CFRP) in strengthening beams could improve the ultimate load capacity of beam up to (160%) over the capacity of the control beam (unwrapped beam)

In this study, a comparison has been made between plain concrete and high strength achieved by concrete using glass fiber of two lengths (6 &1 2mm) for M30 grade of concrete. The test (compression test, split tensile test and flexural strength test) is to be done on the concrete with the addition of glass fibers of various percentages (0.5%, 1.0%, and 1.5%) to total weight of the concrete. Mix design of M30 concrete is to be designed as per IS 10262:2009 and to find out the quantities of ingredients.

Materials:

Concrete is a construction material composed of port land cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. The cement and water form a paste which hardens by chemical reaction into a strong, stone-like mass. The inert materials are called aggregates, and for economy no more cement paste is used than is necessary to coat all the aggregate surfaces and fill all the voids. The concrete paste is plastic and easily molded into any form or troweled to produce a smooth surface. Hardening begins immediately, but precautions are taken, usually by covering, to avoid rapid loss of moisture since the presence of water is necessary to continue the chemical reaction and increase the strength. Too much water, however, produces a concrete that is more porous and weaker. The quality of the paste formed by the cement and water largely determines the character of the concrete. Proportioning of the ingredients of concrete is referred to as designing the mixture, and for most structural work the concrete is designed to give compressive strengths of 15 to 35 MPa

Reinforcement Materials (Glass Fibers):

Normally, fiber is a material made into a long filament with a diameter generally in the order of 10 tm. The aspect ratio of length and diameter can be ranging from thousand to infinity. The functions of the fibers are to carry the load and provide strength, thermal stability, stiffness, and other structural properties in the FRP. Glass fibers are also available as thin sheets, called mats. A mat which is made by both long continuous and short fibers (e.g., discontinuous fibers with a length between 25 and 50 mm) arranged in random and bonded together. The width of such mats is variable between 5 cm and 2 m, their density being roughly 0.5 kg/m^2

Figure: Glass fibers

These are fibers commonly used in the naval and industrial fields to produce composites of medium high performance. Their peculiar characteristic is their high strength

Glass is mainly made of Silicon (SiO_2) with a tetrahedral structure (SiO_4). Some aluminum oxides and other metallic ions are then added in various proportions to either ease the working operations or modify some properties (e.g., S-glass fibers exhibit a higher tensile strength than E-glass).

Typical properties	density (g/cm^3)	young's modulus(Gpa)	Tensile strength(Gpa)	tensile Elongation
High strength	1.8	230	2.48	1.1
high modulus	1.9	370	1.79	0.5
ultra high modulus	20-2.1	520-620	1.03-1.31	0.2

Carbon fibers:

Carbon fiber is the most expensive of the more common reinforcements, but in space applications the combination of excellent performance characteristics coupled with light weight make it indispensable reinforcement with cost being of secondary importance. Carbon fibers consist of small crystallite of turbo static graphite.

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4.0 RESULTS

Plastics, rubber fibers, paints and lacquers are all degraded in sunlight by basically the same free radical mechanism. Similarly, prolonged exposure of GRP under natural weathering which includes moisture, temperature ultraviolet radiation etc. will result in degradation of the material. The mechanical properties of a composite depend on the properties of their components namely the fibers and matrix plus the quality of fiber matrix interface. It was difficult to have uniform composition of glass fiber and resin through-out the material, especially, by hand lay-up process. Therefore, the experimental results show scattering due to the non-uniform composition of GRP produced by hand layup process

The standard GRP specimens were tested after they were exposed to outdoor weathering. The effect on the GRP's tensile strength (Mpa =145 psi), after exposing in the natural environment Minimum of three specimens was tested at each interval and the average results were plotted as It is interesting to note that as the exposure time increases an overall slow decrease in tensile strength of GRP was observed the beams choose the below figures:

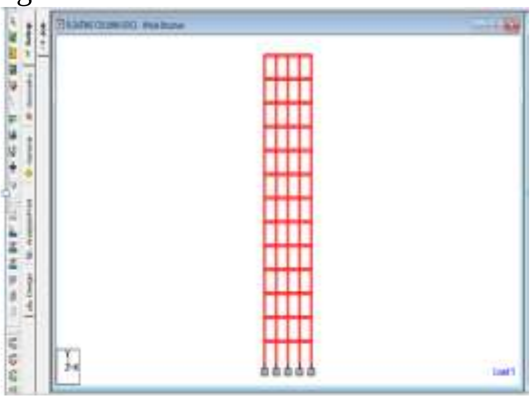


Figure Whole structure of the concrete building

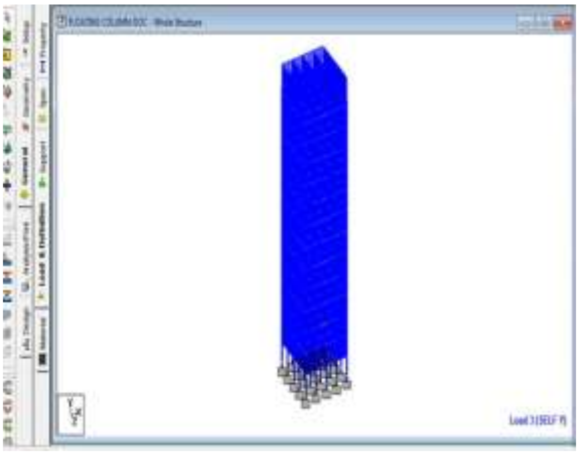


Figure: shows Dead load acting on building

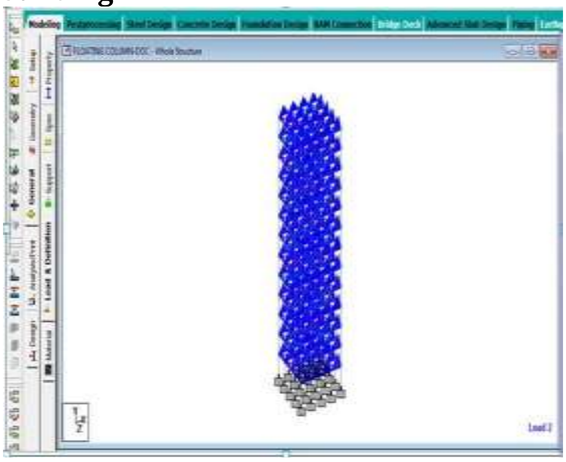


Figure shows Live load acting on building

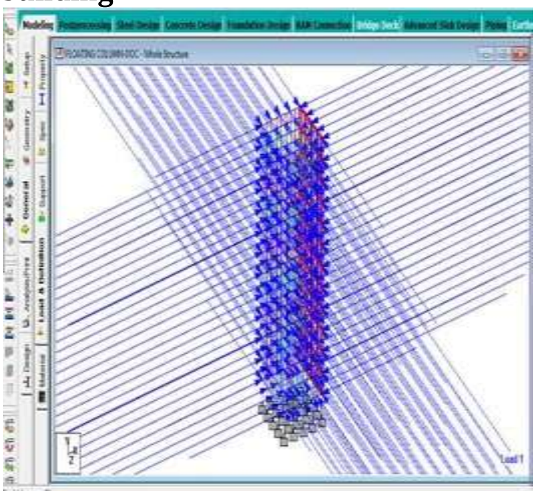


Figure shows Wind load acting on building

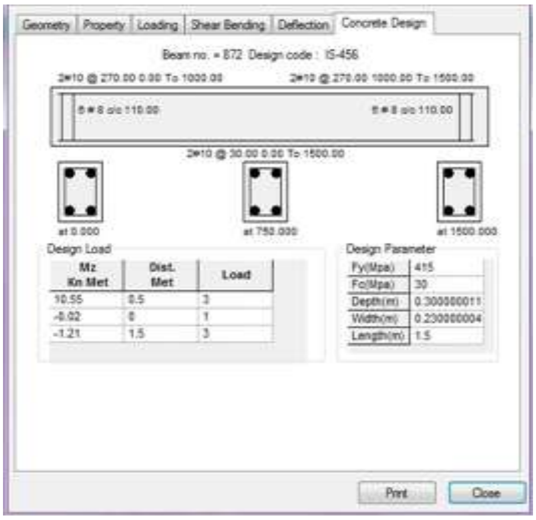


Figure shows Design of Beam

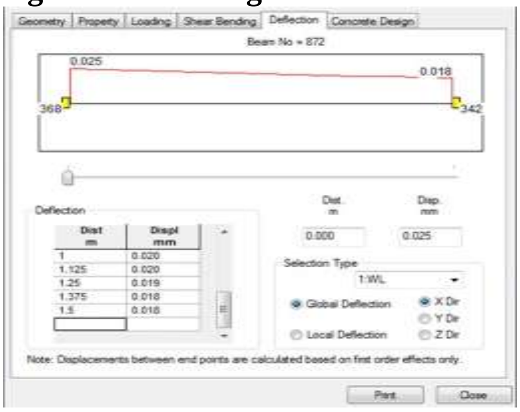


Figure shows Deflection of Beam

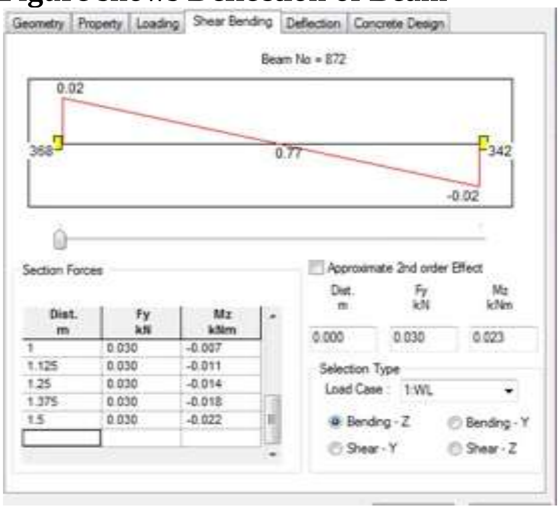
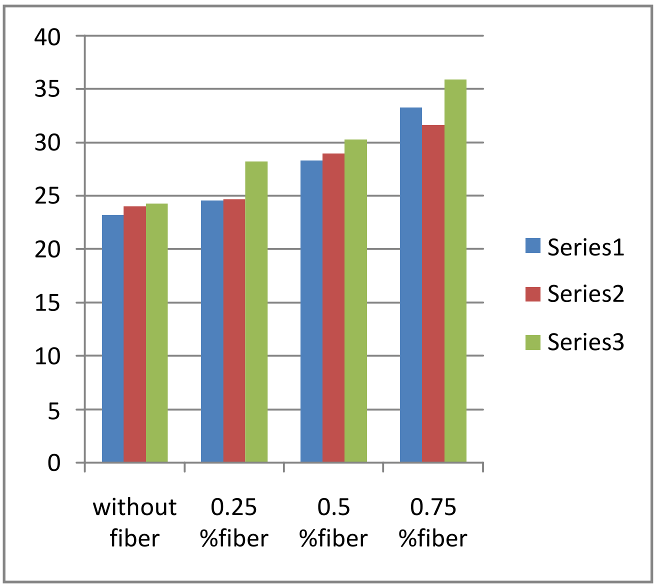


Figure shows shear bending of Beam

Compressive strength of concrete

without fiber	0.25 %fiber	0.5 %fiber	0.75 %fiber
23.2	24.57	28.27	33.21
24	24.674	28.893	31.625
24.24	28.18	30.25	35.89



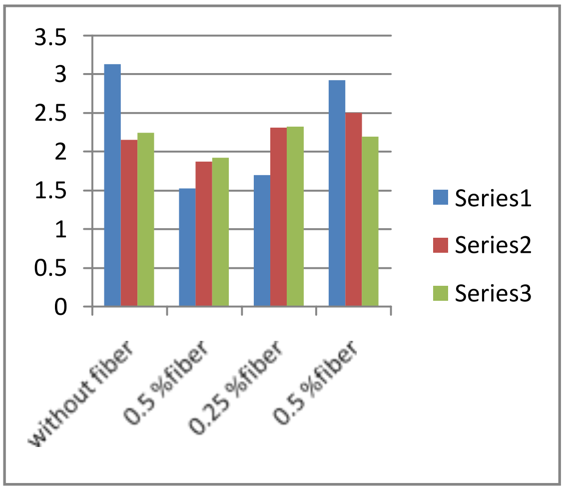
Graph: Compressive strength of concrete

Split tensile strength of concrete:

Concrete may be subjected to tension in very rare cases and is never designed to resist direct tension. However, the load at which cracking would occur is important and needs to be determined. Split Tensile strength of concrete is usually found by testing concrete cubes mould of size 150 mm x 300mm. The tensile strength of concrete as compared to its compressive strength is very low and is found to be only 10-15 % of the compressive strength. There are various factors which influence the tensile strength of concrete like aggregates, age, curing, air entrainment and method of test.

Table: 4.2 Split tensile strength of concrete

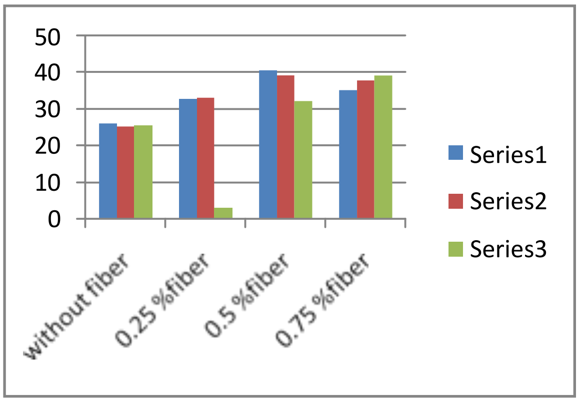
without fiber	0.5 %fiber	0.25 %fiber	0.5 %fiber
3.124	1.5214	1.70	2.92
2.15	1.87	2.31	2.502
2.24	1.92	2.3204	2.193



14 DAYS TEST RES ULTS (IN N/MM2):

Table: 4.4 Compressive strength of concrete 14 days

without fiber	0.25 %fiber	0.5 %fiber	0.75 %fiber
25.9	32.56	40.38	34.98
25.12	32.92	39.0	37.62
25.44	2.93	32.0	39



Graph 4.4Compressive strength of concrete 14 days

28 DAYS TES T RES ULTS (IN N/MM2):

TABLE 4.8 COMPRESS IVE STRENGTH OF CONCRETE

without fiber	**0.25 %fiber**	**0.5 %fiber**	**0.75 %fiber**
3.5	**32**	**38**	**48.39**
3.42	**31.8**	**37.96**	**46**
3.9	**32**	**41.25**	**43**

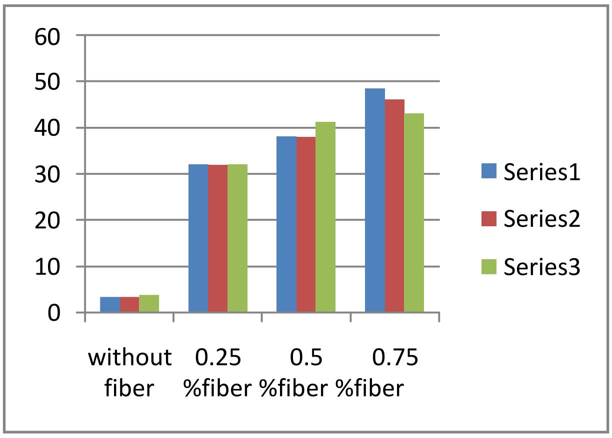


Figure: 4.8 compressive strength of concrete

CONCLUSION

The following conclusions are made from the experimental study of addition of glass fibers of two lengths with same diameter and properties into the concrete mix. In this study of addition of combinational glass fibers greater strength and stiffness than the conventional concrete and also possesses good binding and strength to weight ratio. The compressive strength of concrete are increased with the addition of glass fibers to 0.50% by weight of concrete and further any addition of the glass fiber shows in decreases compressive strength (it is been evaluated by studying research paper and journals on this addition).

- Split tensile strength tends to improve for Material Concrete compared to plain concrete.
- Flexural strength shows tremendous increases from 0.5 to 0.75 % in Material Concrete compared to plain concrete. Whereas by using single fiber addition it gives max strength at 1%.
- Optimum combination of is 0 .75% is obtained as higher properties.
- The overall performance of glass fiber concrete increased strength compared to plain concrete.

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