HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 14, April 2015
e-ISSN: 2321-1814, ISBN (Print): 978-1-62951-946-3

Experimental and Analytical Modeling on Flexural Behavior of E-Glass Fibre Reinforced Concrete Beams

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Abstract

Concrete is a heterogeneous mixture of cement, aggregate and water. The construction industry calls for advanced design for executing turnkey projects. So, concrete should have high strength and good workability to meet the requirements for such projects. The demand for natural fine aggregate is significantly increased due to rapid development in construction activities. In the present investigation, Flexural Behavior of Glass Fiber Reinforced Concrete beam for M25 and M50 grades of concrete are studied. Manufactured sand is used as Fine Aggregate. E-Glass Fiber in varying proportions of 0%, 0.1% and 0.2% by volume of concrete is added. Strength properties such as Compressive strength, Split Tensile, Modulus of Elasticity are determined. Flexural Behavior of GFRC Beam specimens and Conventional Concrete Beam specimens are compared. The first crack load, ultimate load, load versus deflection characteristics, ductility factor and stiffness factor of beams are studied. The analysis part is carried out using ANSYS software. The experimental and analytical results are compared and it was observed that increase in percentage of fiber content to certain extent significantly enhance the strength characteristics, ductility and also reduces the propagation of crack width.

Keywords

Manufactured sand, E-Glass Fiber, ANSYS, Ductility Factor

Introduction

Concrete is a brittle material and the addition of fibers can convert failure mode from brittle to ductile by increasing the tensile strength of concrete. As a result the structural performance of concrete can be improved. Researchers all over the world are attempting to develop high performance concretes by using fibers and other admixtures in concrete up to certain proportions. Research studies proved that the addition of glass fibers to reinforced concrete beam is found to increase its shear strength.

The principle reason for incorporating fibers into the concrete is to increase its toughness, tensile strength and improve the cracking deformation characteristics. There are only

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limited studies have been reported so far on results of the behavior of beams reinforced with a new type of glass Fibrillated mesh fibers. This fiber has higher modulus of elasticity and an optimized geometry to enhance the bond between the fiber and the concrete matrix, which leads to an increase in the toughness properties of concrete. In this work, an attempt is made to incorporate glass fibers in concrete to produce a desired material having appropriate compressive strength, flexural strength and split tensile strength.

Finite element analysis is a numerical method for analyzing complex, structural and thermal problems. Like homogeneous materials, composite materials can also be analyzed using Pre- and post-processor facilities of ANSYS to study its behavior under different load conditions.

The displacements of the concrete structures are small, compared to the dimensions of the structure. Since the concrete is a non-homogeneous material and behaves linearly over a small percentage of its strength, material nonlinearity is considered. Nonlinear finite element analysis is a powerful tool in determining the internal stress, strain distribution in concrete structures. With the aid of nonlinear finite element analysis, it is possible to study the behavior of composite layered concrete structures up to the ultimate load range.

The objective of experimental work is

- To Investigate the Flexural Behavior of Conventional Concrete and Glass Fiber Reinforced Concrete Beams using manufactured sand for different proportions of fiber.
- To Compare Experimental results with Analytical results done using ANSYS software.

Experimental Program

1- Materials

A. Cement

Ordinary Portland cement 43 grade is used in this study for making concrete. The cement is tested for its physical as well as chemical properties and the results so obtained are conforming to IS 8112.

B. Fine Aggregate

Crusher sand was used as Fine Aggregate. The Specific Gravity of Crusher sand is 2.75 and its Fineness Modulus is 2.85 conforming Zone – II.

C. Coarse Aggregate

Coarse aggregate is obtained from local source and tested to conform IS 2386. The tested value of Specific Gravity of Coarse Aggregate is 2.776.

D. Water

The water is potable and its properties have been tested and the results are found to be conforming IS 456.

E. Concrete Admixture

The concrete admixture Sikament 600 HP is used. It is a Type G admixture specified by ASTM C 494.

F. Glass Fiber

E – Glass fiber having Young's Modulus 80Mpa, Poisson's ratio 0.22 and Tensile strength of 2000MPa is used. The aspect ratio is 611.

Experimental Investigation

A. Mix Proportion

Mix Design is done as per IS 10262:2009, IS 456:2000 and SP23. The grades of concrete are M25 and M50.

Table 1: M25 Grade - Mix Proportions for GFRC (Kg/m3)

Sl.No.	Materials		Fiber (%)		
			0%	0.1%	0.2%
1.	Cement		320	320	320
2.	Coarse Aggregate	20mm	689.9	689.9	689.9
		10mm	459.93	459.93	459.93
3.	Fine Aggregate		824.84	824.84	824.84
4.	Water		160	160	160
5.	Admixture		5.12	5.12	5.12
6.	E – Glass Fiber		0	2.46	4.92

The Water / Cement ratio adopted for M25 grade of concrete is 0.5.

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Table 2: M50 – Mix Proportions for GFRC (Kg/m3)

Sl.No.	Materials		Fiber (%)		
			0%	0.1%	0.2%
1.	Cement		400	400	400
2.	Coarse Aggregate	20mm	686	686	686
		10mm	458	458	458
3.	Fine Aggregate		780	780	780
4.	Water		144	144	144
5.	Admixture		5.2	5.2	5.2
6.	E – Glass Fiber		0	2.46	4.92

The Water / Cement ratio adopted for M50 grade of concrete is 0.36.

B. Test Specimens

Moulds such as Cubes (150mm*150mm*150mm), Cylinders (150mm*300mm), Prisms (150mm*150mm*700mm) and Beams (100mm*200mm*1500mm) for M25 and M50 grades of concrete were cast by adding 0%, 0.1% and 0.2% (volume of concrete) of Glass Fiber. The demoulded samples after 24hours were kept in water for a period of 28 days for curing. The cubes and cylinders were tested at the age of concrete for 7 days and 28 days. The prisms and beams were tested for 28 days.

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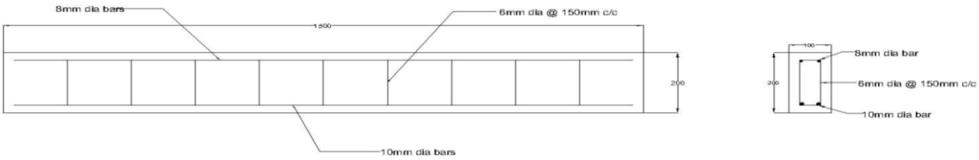
Figure: 1 Casting of Specimens

Figure: 2 Curing of Specimens

C. Testing of Beam Specimens

Beam specimens of size 100mm*200mm*1500mm for M25 and M50 grades of concrete are tested under simply supported condition with two point loading. Load versus Deflection behavior of conventional and GFRC beams were studied. The load was applied gradually and the corresponding deflection was noted using Linear Variable Differential Transformer. The first crack load, ultimate load and crack patterns were observed and recorded.



REINFORCEMENT DETAILS OF BEAM

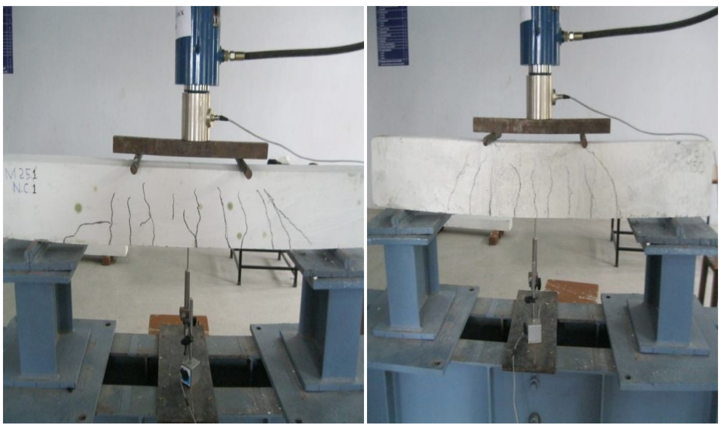


Figure: 3 Testing of Beams – M25 – NC, M50 – NC & M25 – GF, M50 - GF

Analytical Investigation

A. Introduction

The Finite Element modeling of a beam is carried out using ANSYS 12.0 software. Models are created using Graphical User Interface. The analysis part includes Preprocessing, Solution and Post processing. Preprocessing comprises of creating the model, element attribution and meshing. Solution part involves selection of boundary conditions, load calculations and solving the problem. Post processing comprises of interpretation of results.

B. Element Types

Solid 65 elements were used to model of concrete. It has eight nodes with three degrees of freedom. Link 8 (3D spar) were used for reinforcements. This element has two nodes with three degrees of freedom at each node.

C. Real Constants

Real constant set 1 was used for Solid 65. In set 1, no input data will be given because the rebar will be modeled as beam. Real constants set 2, 3, 4 will have Link 8. The values are shown in table below.

Real Constants Set	Element Type		Real constants for Rebar 1	Real constants for Rebar 2	Real constants for Rebar 3
1	Solid 65	Material No	0	0	0
2	Link 8	Area(mm2)	78.5	-	-
		Initial strain	0	0	0
3	Link 8	Area(mm2)	50.24	-	-
		Initial strain	0	0	0
4	Link 8	Area(mm2)	28.26	-	-
		Initial strain	0	0	0

Table 3: Real constants

D. MATERIAL PROPERTIES

The Young's modulus, Poisson's ratio, Stress-Strain values of concrete are considered as input. For reinforcements, Young's modulus, Poisson's ratio and Yield stress of steel are the inputs.

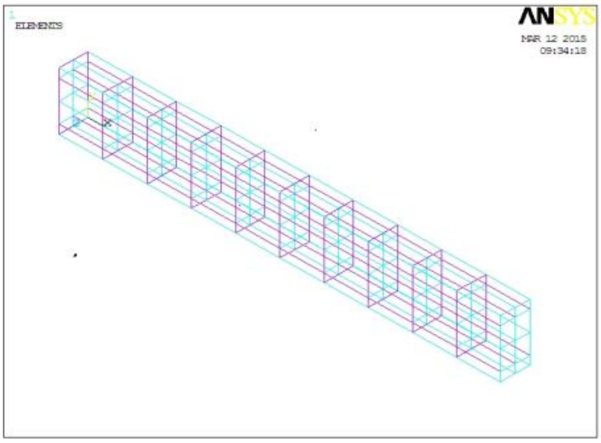


Figure 4: Modeling of Beam

E. Modeling of Beam

The beam was modeled as volume. The length of the beam is 1500mm, width and depth is 100mm and 200mm. The Finite Element modeling of beam is shown below.

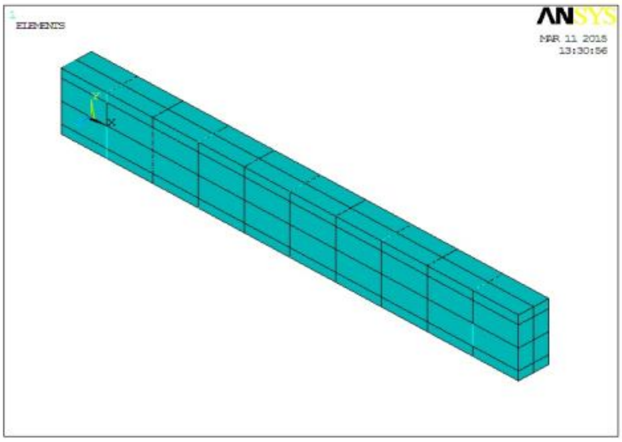


Figure 5: Meshing of Beam

F. Loads and Boundary Conditions

As per the experimental setup shown in Figure 3, the loads and boundary conditions are given as simply supported and two point loading.

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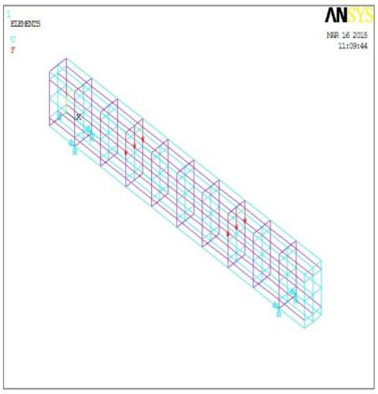

Figure 6: Applying Boundary conditions

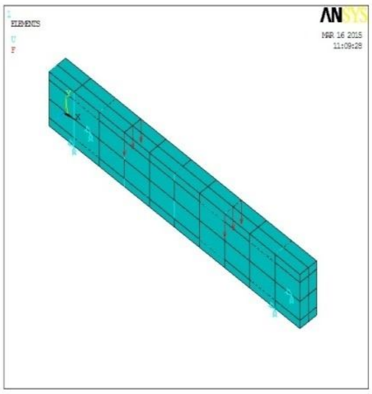

Figure 7: Applying two point loading

Results and Discussion

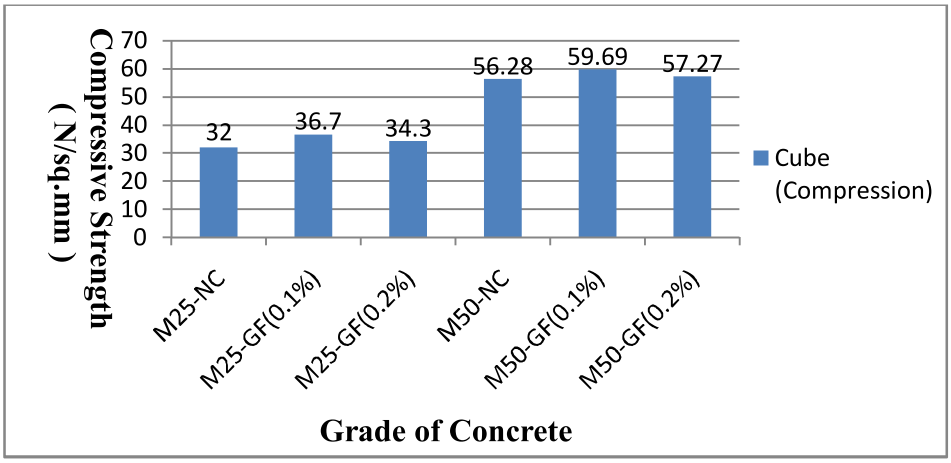

Figure 4: Compressive Strength for M25 and M50 grades – 28 days

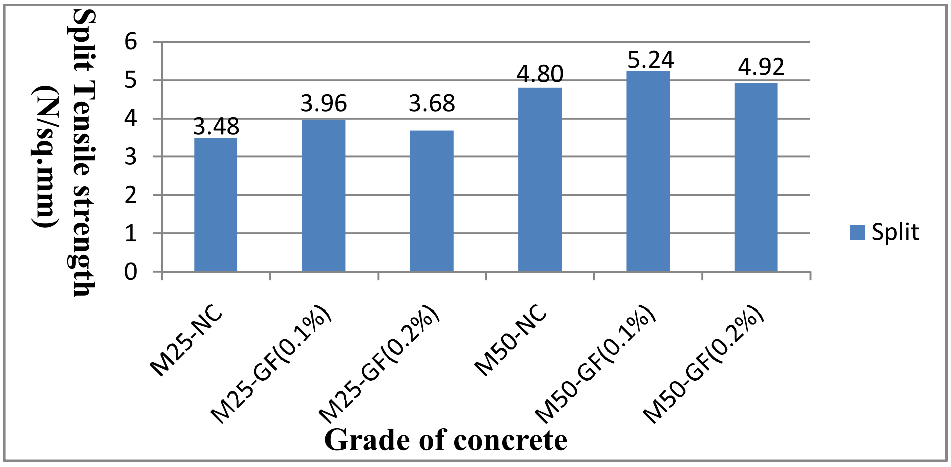

Figure 5: Split Tensile strength for M25 and M50 grades – 28 days

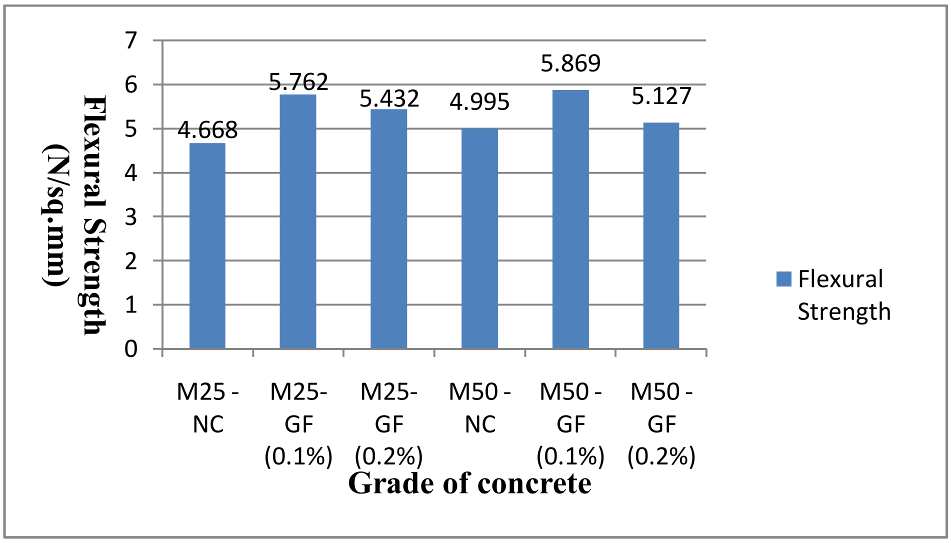

Figure 6: Flexural strength for M25 and M50 grades – 28 days

Table 4: Flexural test results of beams

Beam ID	Experimental				Analytical			
	First Crack Load (kN)	Deflection (mm)	Ultimate Load (kN)	Deflection (mm)	First Crack Load (kN)	Deflection (mm)	Ultimate Load (kN)	Deflection (mm)
M25 – NC	15	3.0	56	8.8	18	3.4	59	9.2
M25 – GF (0.1 %)	22.5	3.1	61	7.7	21	3.6	60	8.1
M25 – GF (0.2 %)	13.5	1.8	48	16	15	2.2	46	17
M50 – NC	43	4.0	100.5	14.2	47	4.8	103	15.4

M50 – GF (0.1 %)	48	5.2	115	13.8	52	5.4	112	13.5
M50 – GF (0.2 %)	40	4.8	95	19.4	44	5.0	90	19.8

Table 5: Ductility and Stiffness factor for M25 and M50 grades

Beam ID	Ductility Factor		Stiffness Factor	
	Experimental	Analytical	Experimental	Analytical
M25 – NC	2.93	2.71	6.36	6.41
M25 – GF (0.1%)	2.48	2.25	7.92	7.41
M25 – GF (0.2%)	8.88	7.73	3.0	2.70
M50 - NC	3.55	3.21	7.07	6.68
M50 – GF (0.1%)	2.65	2.50	8.33	8.30
M50 – GF (0.2%)	4.04	3.96	4.89	4.54

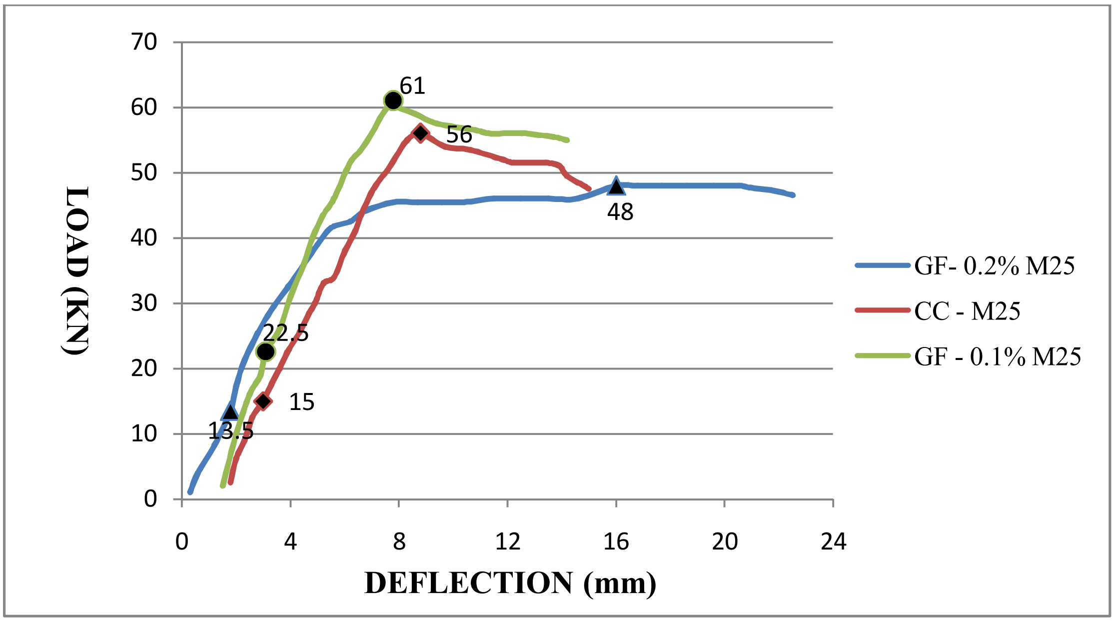

Figure 7: Load versus Deflection curve for M25 grade

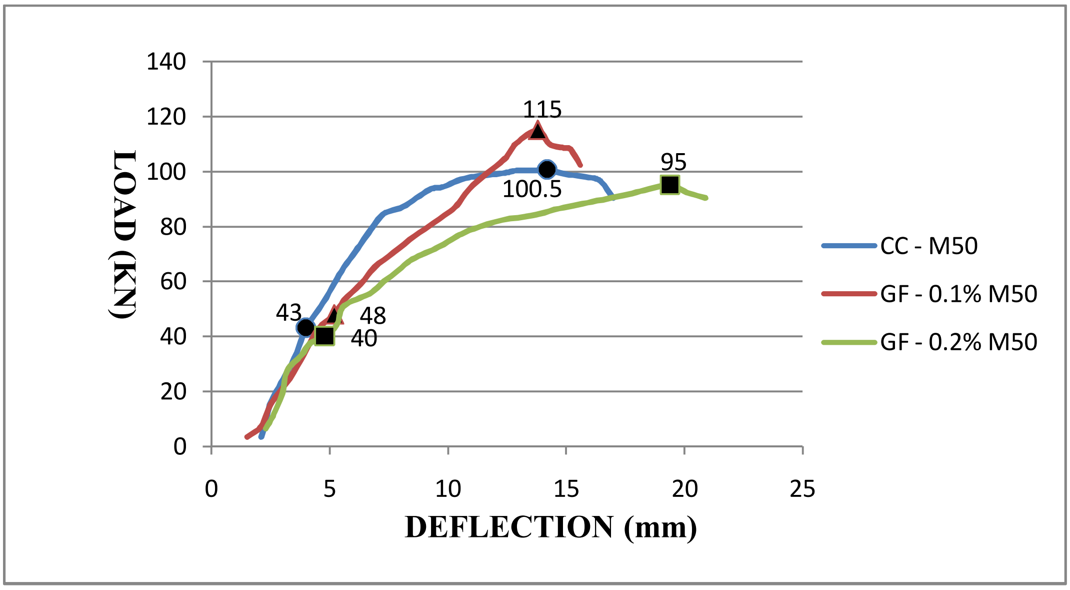

Figure 8: Load versus Deflection curve for M50 grade

The test results of all specimens are given in Tables 4&5. From the results, it is evident that addition of 0.1% of E – Glass fiber by volume of concrete has significantly increased the compressive strength and tensile strength of concrete for both M25 and M50. Addition of 0.2% of E – Glass fiber is decreasing the compressive and tensile strength. E – Glass fiber behaves well with manufactured sand. There is no bleeding and segregation of concrete. Workability is achieved up to 0.1% addition of fiber for both M25 and M50 without any difficulty.

Conclusions

1. In GFRC beams, first crack load and ultimate load increases for 0.1% addition of glass fiber when compared with conventional specimen for both M25 and M50 grades.
2. For 0.2% addition of glass fiber, there is no increase in load carrying capacity of beams when compared with conventional and GFRC beams (0.1%).
3. The glass fiber content of 0.2% shows higher ductility for M25 and M50 grades when compared with 0.1%. So, there will be not be sudden failure and it will give severe warning before collapse.
4. So, it is recommended that, addition of glass fiber of 0.1% is sufficient for both lower grades as well as higher grades of concrete for better outcome of results.
5. The experimental and analytical results showed good agreement with each other.

References

(1) Experimental investigation on fiber reinforced concrete using waste materials,G.Murali, International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 2, Issue 2,Mar-Apr 2012, pp.278-283.

(2) Strength characteristics of glass fiber on bottom ash based concrete, P. Bhuvaneshwari, International Journal of Science, Environment and Technology, Vol. 2, No 1, 2013, 90 – 102.

(3) Experimental analysis of glass fiber reinforced composite beams, Samadhan Garad, International Journal of Advanced Engineering Technology E-ISSN 0976-3945.

(4) Experimental Study on Behavior of Steel and Glass Fiber Reinforced Concrete Composites, Kavita S Kene, Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, No. 4, December 2012.

(5) Comparison of glass fiber reinforced concrete & Geopolymer concrete with glass fiber reinforcement, Shrikant Harle, International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

(6) Comparative study of experimental and analytical results of frp strengthened beams in flexure, Shaishav R. Viradiya, International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

(7) Moment-curvature relationship of glass fiber reinforced self-compacting recycled aggregate concrete, Prasad M. L. V., Journal of Environmental Research And Development Vol. 7 No. 2A, October-December 2012.

(8) Finite element analysis and comparative study of reinforced concrete beams laminated with and without frp, Prateek Shrivastava, International Journal of Engineering & Science Research, ISSN 2277-2685 IJESR/Jan 2015/ Vol-5/Issue-1/12-18.

(9) Strength Aspects of Glass Fiber Reinforced Concrete, Avinash Gornale, International Journal of Scientific & Engineering Research, Volume 3, Issue 7, July-2012 1 ISSN 2229-5518.

(10) Flexural behavior of reinforced and prestressed concrete beams using Finite element analysis, Anthony j. wolanski, B.S., a thesis submitted to the faculty of the graduate school, Marquette University, May, 2004.

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