EXPERIMENTAL STUDY ON GLASS FIBER REINFORCED CONCRETE MODERATE DEEP BEAM

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ABSTRACT: The use of concrete moderate deep beams is gaining rapid popularity in modern construction industry due to space required free from columns. the fiber addition improves the toughness, the shear strength, the flexural strength, and reduce the creep strain and shrinkage of concrete. The present work deals with the results of the experimental investigations on performance of Glass fiber reinforced concrete moderate deep beam. Glass fibers of 12mm cut length are used. Fiber content of 0.25%, 0.50%, 0.75% and 1% by volume of concrete & water cement ratio of 0.43% kept constant for all beam. Testing are carried out on four series of beams & for each series cube & cylinder were cast. After curing for 28 days compressive strength test, split tensile strength test and two point loading test on moderate deep beam was conducted in hardened state. Effect of variation beam depth and volume fraction on fresh and hardened concrete is studied in detail. Relation between compressive strength, split tensile strength Vs volume fraction for different beam depth are developed. Behavior of moderate deep beam in terms of load Vs deflection has studied. Cracking pattern of the deep beams is also studied in detail. Comparison of results of moderate deep beam with longitudinal reinforcement with stirrups and that of GFRC moderate deep beam along with longitudinal reinforcement without stirrups showed the significant improvements in the results.
Keywords: moderate deep beams, Glass fiber reinforced concrete, GFRC.

1. INTRODUCTION

As per IS: 456 (2000) clause 29.1, beams can be classified into three categories namely normal or shallow beams, moderate deep beams, and deep beams. These classifications are based on their span to depth or shear span to depth ratio.

- Shallow beam ($L/D \geq 6.0$)
- Moderate beam ($2.0 < L/D < 6.0$)
- Deep beam ($0.5 < L/D \leq 2.0$)

Moderate deep beams and deep beams have a wide application in structural engineering field. An attempt has been made through this dissertation to understand the complex but most significant shear strength & flexural strength response of moderate deep beams under fibrous matrix as they predominantly fail under shear. Because of their proportion they develop mechanism of shear transfer quite different from that in slender beams and their strength is likely to be controlled by shear rather than flexure provided with nominal amount of longitudinal reinforcement. A very little works have been reported on shear strength and flexural deformational behavior of fibrous Reinforced Cement Concrete moderate deep beams, related to the study of crack pattern. Moderate deep and deep beams are shear predominant members and generally fail in brittle shear mode.

OBJECTIVES

The objective of this study is to investigate the performance of GFRC Moderate Deep Beam in fresh as well as in hardened state with various span to Depth Ratios and volume fractions of glass fiber. In this project Glass fibers of 12mm cut length with 0.25%, 0.50%, 0.75% & 1 % by volume of concrete & various span –to-Depth Ratios of 2, 2.4, 3 & 4 are used. Testing are carried out on four series of beams & for each series cube & cylinder were cast. After curing for 28 days compressive strength test, split tensile strength test and two point loading test on moderate deep beam was conducted in hardened state. Effect of variation beam depth and volume fraction on fresh and hardened concrete is studied in detail. Relation between compressive strength, split tensile strength Vs volume fraction for different beam depth are developed. Behavior of moderate deep beam in terms of load Vs deflection has studied. Cracking pattern of the deep beams is also studied in detail.

2.MATERIAL PROPERTIES:

Table 1: Cement Properties.

Sr. No.	Description of Test	Results
01	Fineness of cement (residue on IS sieve No. 9)	7 %
02	Specific gravity	3.15
03	Standard consistency of cement	29 %
04	Setting time of cement a) Initial setting time b) Final setting time	 63 minute 442 minute
05	Soundness test of cement (with Le-Chatelier's mould)	3 mm
06	Compressive strength of cement: a) 3 days b) 7 days	 16.36 N/mm^2 31.08 N/mm^2

Table 2: Physical properties of Fine Aggregate (sand)

1.1.1Sr. No	Property	Results
1.	Particle Shape, Size	Round, Below 4.75mm
2.	Fineness Modulus	4.175
3.	Silt content	3%
4.	Specific Gravity	2.652
5.	Surface moisture	Nil

Table 3: Physical Properties of Coarse Aggregate.

Sr. No	Property	Results
1.	Particle Shape, Size	Angular, 20mm
2.	Fineness Modulus of 20mm aggregates	7.424
3.	Specific Gravity	2.664
6.	Surface moisture	Nil

Glass fiber (Chopped Strands):

Glass fibre is a recent introduction in making fibre concrete. It has very high tensile strength 1020 to 4080 N/mm^2. The alkali resistant glass fibre reinforcement in concrete shows considerable improvement in durability also. Since the fibres cannot rust like steel, there is no need for a protective concrete cover thickness to prevent rusting.

Figure 3.1: glass fibres Strands (12mm) used as a reinforcing concrete

With the thin, hollow construction of GFRC products, they can weigh a fraction of the weight of traditional precast concrete. glass fibre shall be an alkali resistant, continuous filament fibre developed and to have high strength retention in ordinary Portland cement environments.

Table 4: Physical Properties of Glass Fiber Chopped Strands (supplied by manufacturer)

Sr.No.	Properties	Values
1	Length	12mm
2	Softening point	773ºC
3	Sp.Gravity	2.7 gm/cc
4	Elongation	4.4%
5	Tensile strength	1700N/mm^2
6	Youngs modulus	73.1 gpa
7	Refractive Index	1.562
8	Diameter	0.012mm

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MIX DESIGN OF CONCRETE:

Table 3: Summary of Concrete Mix Design

Observation and Calculation		
1	Characteristic strength	25 N/mm^2
2	Level of quality control	Good
3	Standard deviation (S)	5.3
4	Mean target strength, $F_t = f_{ck} + 1.65xS$	33.75 N/mm^2
5	W/C ratio	0.43
6	Type of cement	OPC
7	Nominal size of coarse aggregate	20 mm
8	Specific gravity of cement, S_c	3.15
9	Specific gravity of fine aggregate, S_{fa}	2.652
10	Specific gravity of coarse aggregate, S_{ca}	2.664
11	% of entrapped air	2%
12	Water content per m^3 of concrete	186 Kg/m^3
13	Ratio of fine aggregate to total aggregate by absolute volume	31.6%
14	Cement content for W/C = 0.43	432.55 Kg/m^3
15	Total fine aggregate per m^3 of concrete, F_a	550.32 Kg/m^3
16	Total coarse aggregate per m^3 of concrete, C_a	1196.59 Kg/m^3

3. TEST RESULTS AND DISCUSSIONS

Fresh Concrete Test Results:

Workability tests are conducted on normal concrete with and without polypropylene fibers in fresh state. Throughout the experimentation water cement ratio 0.43 kept constant.

The variation of slump in relation to volume of fiber is as shown in table 4.1.Slump test is most commonly used method of measuring workability of concrete which can be employed either in laboratory or at site. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

Table 4.1: Workability by Slump Cone Test

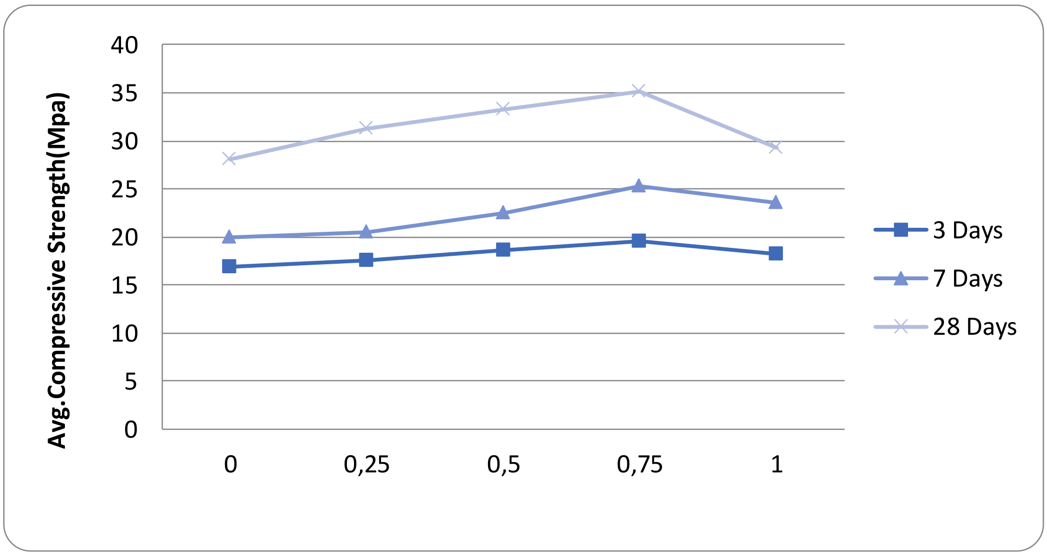
Volume of Fiber (%Vf)	Slump (mm)	Degree of Workability
0	145	High
0.25	110	High
0.50	85	Medium
0.75	70	Medium
1	50	Medium

Hard Concrete Test Results:

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete work. Tests are made by casting cubes and cylinder from the actual concrete. The samples are tested for compressive strength test, split tensile strength for 3days, 7days and 28 days, and flexural test samples are tested only for 28 days.

Compression Strength Test:

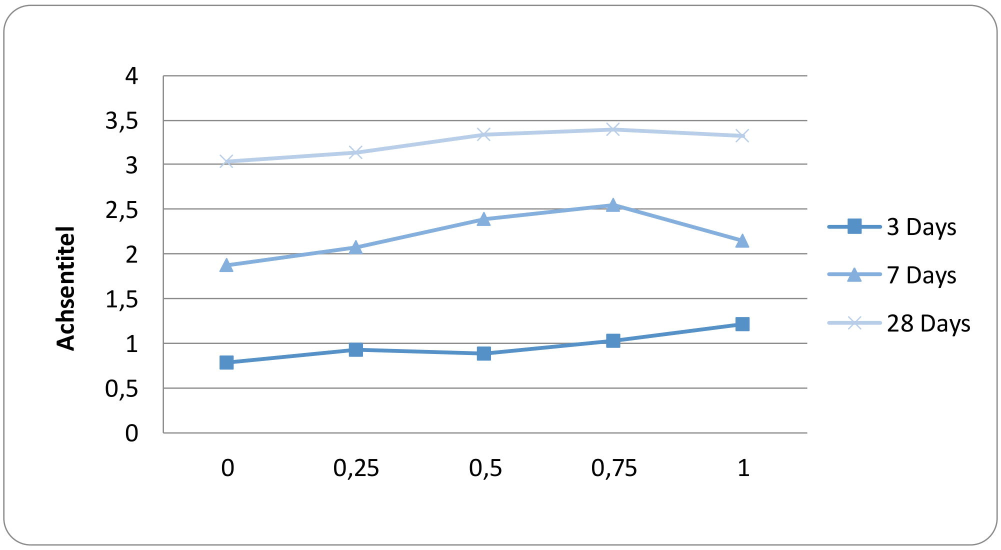
The variation of compressive strength with respect to Volume of fiber (V_f) is shown in the graph



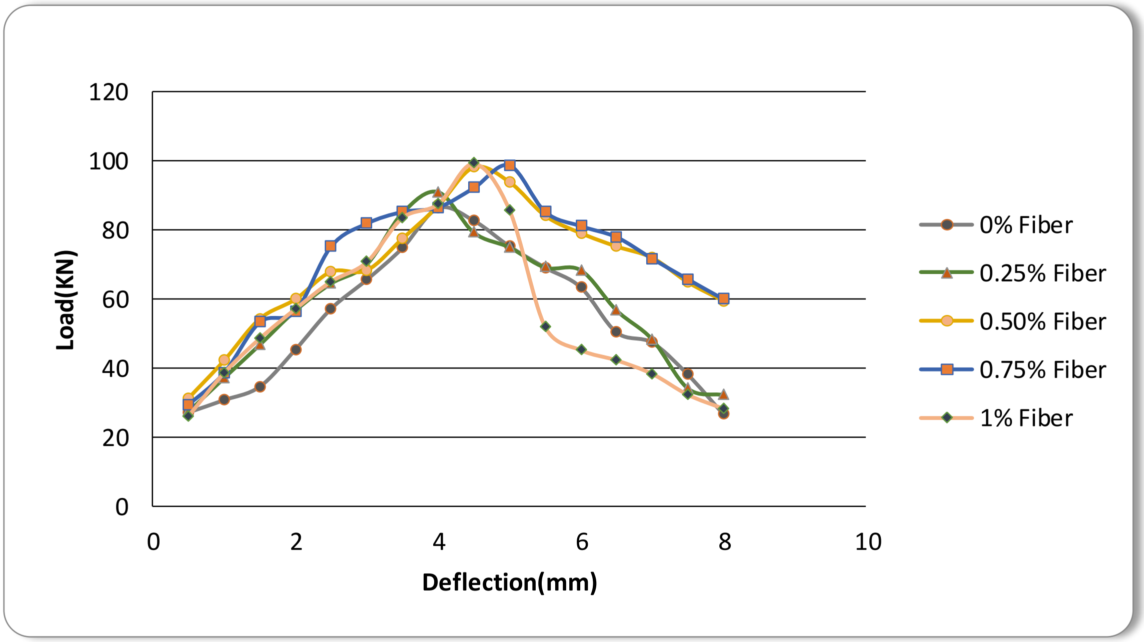
Graph 1: Avg.Compressive Strength Vs % Fiber Volume Fraction(Vf)

Split Tensile Strength Test:

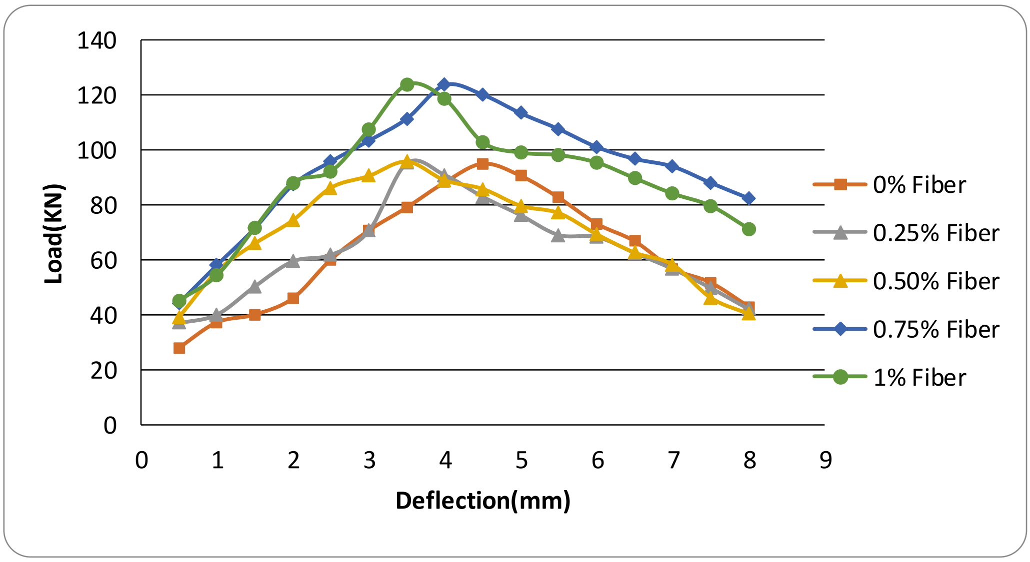
The variation of split tensile strength with respect to fiber volume fraction (Vf) is shown in the graph



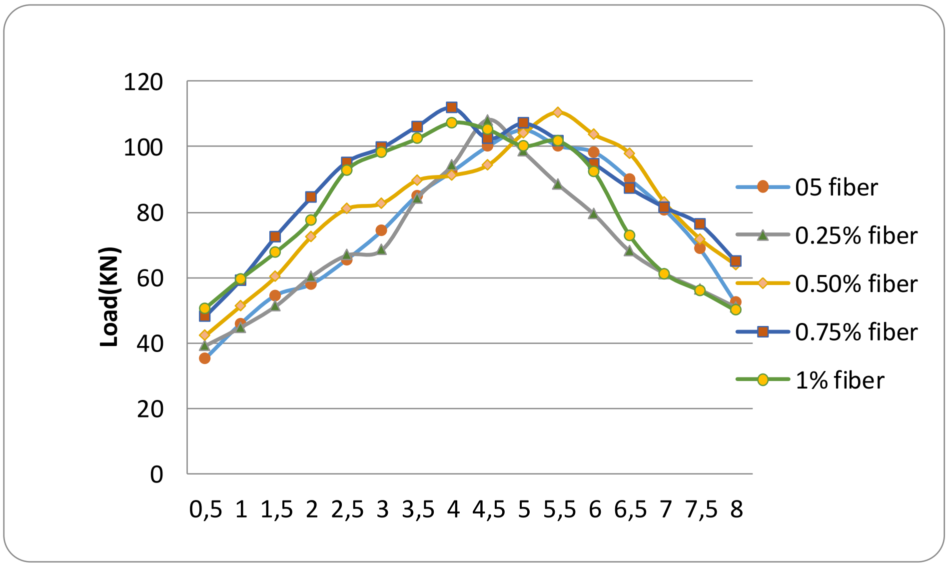
Graph 4.2: Split tensile Strength Vs % Fiber Volume Fraction



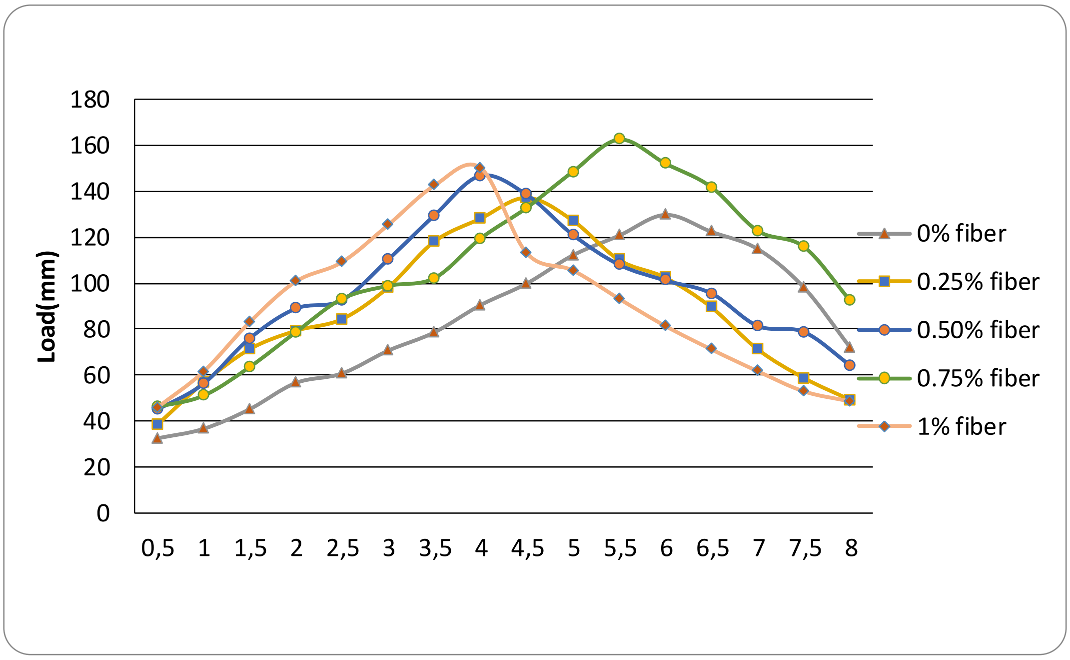
Graph 4.3: Load Vs Deflection for moderate deep beam with & without Glass fiber (L/D=4)



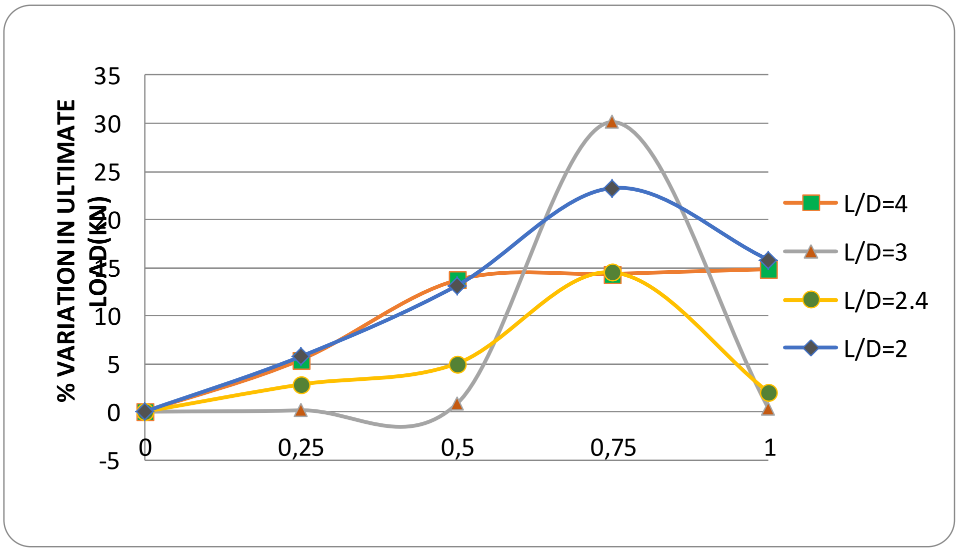
Graph 4.4: Load Vs deflection for moderate deep beam with & without Glass fiber (L/D=3)



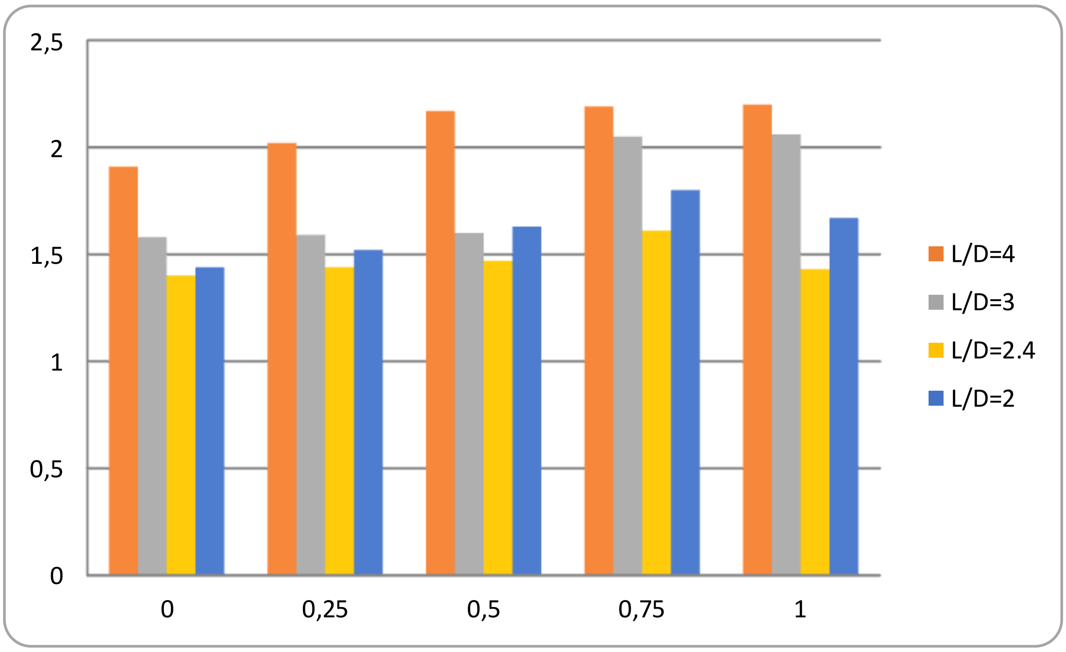
Graph 4.5: Load Vs deflection for moderate deep beam with & without Glass fiber (L/D=2.4)



Graph 4.6: Load Vs Deflection for moderate deep beam with & without Glass fiber (L/D=2)



Graph 4.8: % Variation in ultimate load Vs % fiber volume fraction (Vf) for moderate deep beam with & without Glass fiber



Graph 4.10: Flexural shear strength Vs % Fiber volume fraction (Vf) for moderate deep beam with & without Glass fiber

CONCLUSION

Following conclusion are drawn on the result discussed in the previous chapter:

1) Form the result obtained for the workability test, it can be concluded that workability of concrete decreases with increase in volume fraction.
2) The increase in average compressive strength for GFRC is found to be 0.75 %. Compared to PCC. The maximum compressive strength is achieved with 0.75% fiber volume fraction and decrease to some extent to the 1% fiber volume fraction.
3) The maximum compressive strength, spilt tensile strength and of concrete achieved are 35.10MPa, 3.39MPa respectively at 28 days for the 0.75% of glass fibers.
4) In general, the significant improvement in the load carrying capacity of moderate deep beam is observed with the inclusion Glass fibers. However maximum gain in ultimate load carrying capacity of moderate deep beam is observed with increase in volume fraction upto 0.75% but constant somewhat to L/D ratio 4 & 3.
5) The ultimate load carrying capacity of moderate deep beam is observed to be maximum with 0.75% volume fraction for L/d ratio 2.4 & 2 but decrease again to 1% fiber volume fraction.

6) The Glass fiber moderate deep beams shows the greatest difference between first crack and ultimate crack strength.
7) In this experimental work the crack pattern under loading on moderate deep beam is seen similar in all the cases. The crack is seen prorogating from support towards the point of application of load.
8) In majority of beams of series L/D= 2; the major diagonal shear cracks were formed all of sudden. these cracks were emerged from D/3 to D/4 height of beam from bottom and rapidly extended towards nearest load and support point.
9) Balling effect and Heterogenity in the concrete is observed with higher volume fraction such as 0.75% & 1% volume fraction of Glass fiber.

5. SCOPE FOR FUTURE WORK

The present work has good scope for future research. Some of the research areas are as follows:

- Present study may be continued with variation in grades and types of cement.
- Effect due to variation of span to depth ratio can be studied
- Study can be carried further with change in loading configuration.
- Workability and strength criteria of reinforced concrete may be assessed by using some other sizes and types of fibers
- Further research work may be continued by varying higher percentage volume fraction of fibers

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