Flexural Behaviour of Confined Fibers Reinforced High Strength Concrete Beams

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Abstract- Concrete is a widely used building material because of its special properties, such as high compressive strength and durability. The use of cement in the construction field has increased as urbanization has expanded. Many studies are currently underway in the era of urbanization to use western concrete material in construction to minimize construction costs. At present it is known that the ductility of concrete can be improved by confining the concrete with steel binders and such concrete being called as confined concrete. The spacing limitations of stirrups, limit the confinement offered by stirrups. To overcome this, the confinement with fibers and wire mesh has been suggested as one of the alternative. The investigation on fibers confined reinforced concrete beams revealed that the additional confinement due to combination of wire mesh and fiber reinforcement arrest the cracking, ultimate load as well as ductility of the composite. The stiffness of the beam increases due to confinement with wire mesh, glass fibers and steel fibers

Index Terms- wire mesh, glass fibers, flexibility, ductility, stiffness

I. INTRODUCTION

The development of high strength concrete has been taken place in the last thirty years or so. Due to industrial demand the development of high strength concrete have improved rapidly because the industrial demand of new features in concrete members with serious advantages such as increased capacity and stiffness. The confining reinforcement increases ductility and compressive strength of concrete under compression by resisting lateral expansion due to Poisson’s effect upon loading. The behaviour of confined concrete depends on the effectiveness of the confinement, which in turn is affected by several important variables such as helical pitch, helix yield strength and helix bar diameter. There is no confining effect after loading, until a particular lateral stress due to Poisson’s effect is reached and then the confinement commences. Confinement does not increase strength or ductility initially, but when the axial stress is about 60% of the maximum Cylinder strength, the concrete is effectively confined In the past, Attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced and also by pressurising techniques. Although both these methods improve tensile strength of the concrete members, they however, do not increase the inherent tensile strength of concrete itself.

Historical Perspective

The concept of using fibers as reinforcement is not new. Fiber has been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into being and fiber reinforced concrete was one of the topics of composite materials came into being and fiber reinforced concrete was one of the topics of interest. There is a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibers such as polypropylene fiber were used in concrete, and research into new fiber reinforced concrete continues today.

- *Effect of Fibers in Concrete*

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, so it cannot replace moment resisting or structural steel reinforcement. Some fibers reduce the strength of concrete.

Some Developments in Fiber Reinforced Concrete

Fiber reinforced concrete is composite obtained by a single type (steel or glass fiber) or a blend (steel+glassfibers) of fibers to the concrete mix. teel fibers are used reinforced concrete adding mechanical properties that can be used for Structural design purpose. Adding fibers to concrete improves mechanical properties:

- Increases toughness
- Increases ductility and flexural resistance
- Gets higher and more stable tensile strength
- Increases shear resistance

II. REVIEW OF LITERATURE

Marine Curing Of Steel Fiber Composites," May 1989 Banthia, N. and Foy, C. ; A study is reported which compared the effects of normal and sea water curing on the long term pull-out behavior of steel fibers embedded in cementitious matrices. The effects of silica fume addition and temperature of curing on the durability of a single fiber unit were also studied. It was found, based on a limited number of tests, which the marine curing of steel fiber concrete appears to be acceptable only at very low (less than 2 deg C) ambient temperatures. High temperatures promote early corrosion and lead to strength reductions. The silica fume does not appear to enhance corrosion. Preferential anodic pitting is possible at the deformed locations in the fibers, perhaps due to residual stresses. This finding is relevant in the manufacture of fibers for marine applications.

Ezeldin, A.S .and Balaguru P.N."Bond Behavior Of Normal And High Strength Fiber Reinforced Concrete" Sep-Oct 1989 Experimental results on the bond behavior of normal and high-strength concrete made with and without fibers are reported. A total of 18 mix proportions were investigated. The fiber lengths and reinforcement bar sizes were 30, 50, and 60 mm and #3, 5, 6, and 8 (9, 16, 19 and 25 mm) respectively. The bond tests were conducted using a modified pullout test in which the concrete surrounding the bar was in uniform tension. Addition of silica fume results in higher bond strength but causes brittle bond failure. Fibers can be used to improve the ductility to a considerable extent. The slip (relative movement between the bar and the concrete) at maximum bond load increases with increase in fiber content. Post peak behavior is improved substantially by the fibers.

III. METHODOLOGY

The experimental investigation consists of casting & testing twelve series (HB, HBC-1, HBGF-1, HBSF-1, HBGF, HBSF).The first series is being the control beam designated as "HB" and "HBC-1" series is confined reinforced concrete beams with same mix proportion as that provide in the control beam. And "HBGF-1" series is using glass fibrous unconfined reinforced concrete beams with same mix proportion as that provide in the control beam. "HBSF-1" series is using steel fibrous unconfined reinforced concrete beams with same mix proportion as that provide in the control beam. And "HBGF" series is glass fibrous confined reinforced concrete beams with same mix proportion as that provide in the control beam. And "HBSF" series is steel fibrous confined reinforced concrete beams with same mix proportion as that provide in the control beam. The 12 series of beams were tested under flexural loading. For each group, two beams were tested and the average is taken as the representative response of the corresponding beam.

Materials Used

Cement, Fine Aggregate, Coarse Aggregate, Glass and Steel Fibers, Silica fume

Silica Fume:

Silica Fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

Mix proportion:

The mix used is 1:1.472:3.043 with water cement ratio0.33 compressive strength of concrete is found to be 56.6Mpa while the split tensile strength of the same is found to be 5Mpa.

Casting

The required quantities of the materials for casting one batch of beams are mixed thoroughly on a platform to get a uniform mix. Hand mixing was adopted for concrete preparation then the reinforcement cage was kept on cover blocks in the mould. Then the steel fiber, glass fiber concrete is placed in central 400mm length in each beam.

Testing Procedure

All the beams removed from the curing tank were white washed. Which facilitate the crack observation during the testing? The beams were tested on ultimate testing machine of 40ton capacity. The load is transferred as two point symmetrical load through a rigid steel girder as shown in the test set up photograph. The span of the beam between the support is 1800mm. thus the flexure span is 400mm. the beams are lunched on the I-Girder of length 2.2m,which is placed on the cross head of the UTM.

Three dial gauge of least count 0.01mm are used to measure the deflections under the load points and mid span. A set of dial gauges of least count 0.002mm is attached to the curvature frames to measure the curvature of the beams. The apparatus used for curvature measurement was presented in figure. The crosshead of the machine is raised until the fixed head of the machine just touches the rollers placed at the center of loading beam. All the beams are tested under load rate control the deflection gauge reading are noted at each interval. The crack patterns were drawn directly on the beam and test is continued until the ultimate load is reached. The cracking load and ultimate load are recorded.

Objective:

1. Control and reduce crack sizes due to early-age shrinkage Improve flexural and shear strength. Improve load capacity and ductility. Increase toughness and abrasion resistance.
2. Ensure structures have an acceptable probability of performing satisfactorily during their intended life, though some uncertainty exists
3. Ensure structures can sustain all loads during construction and use while deforming within prescribed limits.

IV. RESULTS

The test results, discussions pertaining to the behaviour of the fibrous confined reinforced concrete beams tested in this phase of investigation are presented.

General Behaviour of Beams

In the test programmed, all the beams cast as under reinforced beams. The term under reinforced mean that the unconfined reinforced concrete sections are designed to fail in tension only. The behaviour of control beams is similar to the behaviour of fibrous confined reinforced concrete beams up to 65 to 70 percent of the ultimate load of corresponding fibrous confined reinforced concrete beams. The visible cracks developed at 60 to 70 percent of ultimate load of each beam. The first flexural crack formed outside the fiber zone. The visible cracks propagated into the compression zone slowly, indicating the upward movement of the neutral axis towards the compression zone. The crack pattern along the length of the beam indicates that, the presence of fibers with higher specific surface factor arrested the propagation of cracks. The strain distribution along the depth of the units was linear up to the cracking load in all the members i.e., (control beams and steel fibrous and glass fibrous confined reinforced concrete beams).

Behaviour under Flexural Loading:

The salient features of the test results were shown in the table. The strain distribution along the depth of the units is linear up to the cracking load in all the members(i.e., control beams and fibrous confined reinforced concrete beams).the load deflection curves of the all specimens have indicated linear behaviour up to about cracking load. After the cracking, the load deflection curves deviated from linearity and become non-linear.as the applied approaches to ultimate load, several new cracks were formed at finite spacing. The specimen is then maintained approximately, the same load level with the increasing deflection. But the cracks continued to penetrate deep into the top layers of specimens. At this stage no crushing of the concrete was observed on the compression zone. Further increase in deflection was associated with a drop in the applied load.

Test result of confined reinforced concrete beams HB, HBC-1, HBSF-1, HBGF-1, HBSF, HBGF

S. NO	Designation of the specimen	Ast	Vcr (KN)	Vu (KN)	Mcr (KN-m)	Mu (KN-m)
1	HB	226	27.5	53	19.25	37.1
2	HB	226	28.5	52	19.95	36.4
AVERAGE			28	52.5	19.6	36.75

S. NO	Designation of the specimen	Ast	No of Layers	% FRCC	Vcr (KN)	Vu (KN)	Mcr (KN-m)	Mu (KN-m)
1.	HBSF-1	226	0	1	39.5	58	27.65	40.6
2.	HBSF-1	226	0	1	40.5	57	28.35	39.9
AVERAGE					40	57.5	28	40.25

S. NO	Designation of the specimen	Ast	No of Mesh Layers	% of fiberc	Vcr (KN)	Vu (KN)	Mcr (KN-m)	Mu (KN-m)
1.	HBC-1	226	1	0	40.5	57	28.5	39.9
2.	HBC-1	226	1	0	39.5	58	27.65	40.6
AVERAGE					40	57.5	28.075	40.25

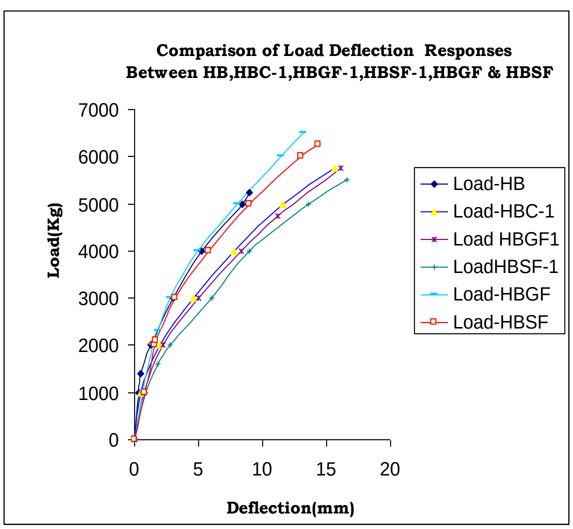
Sl. No	Designation	Ast	Mesh Layers	% of fiber RCC	Vcr (KN)	Vu (KN)	Mcr (KNm)	Mu (KNm)
1.	HBGF-1	226	0	1	31.5	54	22.05	37.8
2.	HBGF-1	226	0	1	32.5	56	22.75	39.2
AVERAGE					32	55	22.4	38.5

	Designation	Ast		% of fiber	Vcr (KN)	Vu (KN)	Mcr (KNm)	Mu (KNm)
1.	HBSF	226	0	1	23.5	64.5	16.4	45.15

2.	HBSF	226	0	1	22.5	65.5	15.75	45.85
AVERAGE					23	65	16.075	45.5

	Designation	A st		% of fiber	Vcr (KN)	Vu (KN)	Mcr (KNm)	Mu (KNm)
1.	HBGF	226	0	1	21.5	62	15.05	43.4
2.	HBGF	226	0	1	20.5	63	14.35	44.1
AVERAGE					21	62.5	14.7	43.75

Graph Shows Comparisons of Load Deflection Responses Between HB, HBC-1, HBGF-1, HBSF-1, HBGF & HBSF



CONCLUSION

1. There is an improvement of curvature in fibrous reinforced (both steel &glass fibers) beams of about 45% & 25% respectively compare to control beams.
2. The provision of confinement at critical sections increase the cracking moment.
3. The post ultimate behaviour of confined sections resembles that of steel section it has large deformation plateau.
4. The provision of confinement improves the flexural behaviour of steel fibrous confined R.C beams.
5. Reinforcing the concrete with steel fibers in the flexure zone alone improves cracking and ultimate load about 43% & 28% respectively compared with control beam (HB).
6. Reinforcing the concrete with glass fibers in the flexure zone alone improves cracking and ultimate load about 22% & 14% respectively compared with control beam (HB).
7. The improvement of cracking and ultimate loads in confined steel fibrous reinforced concrete beams is of about 64% & 44% and 15%and 13% respectively compared to control and steel fibrous reinforced concrete beams.
8. The improvement of cracking and ultimate loads in confined glass fibrous reinforced concrete beams is of about 50% & 38% and 32% and 14% respectively compared to control and glass fibrous reinforced concrete beams.
9. The crack width reduces to 0.50mm in fibrous confined R.C beams where as the crack width in control beams 1.10mm

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